

Review DRAFT

Puget Sound Naval Shipyard Project ENVVEST Technical Work Master Plan

Review Draft

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Prepared By

PSNS Project ENVVEST Technical Steering Committee

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Executive Summary

Introduction

An alternative model for developing and implementing new environmental regulations within the clean water act is being tested through an ENVironmental inVESTment Project Agreement (ENVVEST) among the Puget Sound Naval Shipyard, (PSNS) the Environmental Protection Agency, (EPA) and the Washington State Department of Ecology (Ecology). This model will specifically address the development of Total Maximum Daily Loads (TMDL)s for the Sinclair/Dyes Inlet surface water system adjacent to Puget Sound Naval Shipyard. This technical work master plan defines the goals, objectives, and technical approach planned for [Phase I of the PSNS Project ENVironmental InVESTment \(ENVVEST\)](#). Based on inputs from regulatory requirements, stakeholder involvement, community concerns, and available resources, this technical work master plan has been developed to meet the project goals and milestones defined by the ENVVEST Project Management Team.

Background

The current regulatory process within the Clean Water Act has grown less and less effective as the relative impact of point sources has declined and the impact of non-point sources has increased. Non-point sources are far more difficult to regulate because, by definition, they are not associated with a specific process, or potentially responsible parties that can be brought to justice and made to pay for cleaning up the mess. Because everyone is responsible for non-point pollution its regulation is far more complex and contentious.

Currently, regulatory agencies are being required by court order to rapidly produce thousands of TMDLs with little or no new resources.¹ The regulated community is frustrated by a sense of having reached a point of diminishing returns with respect to their ability to further reduce discharges from their processes. Finally, community stakeholders view the process, the regulatory agencies, and the regulated community with a fair amount of distrust.² Together these

¹ Saltman, T. 2001. Making TMDLs work. *Environment Science and Technology*, 35:11 pp248a-254a.
http://pubs.acs.org/subscribe/journals/esthag-a/35/i11/toc/toc_i11.html

² National Research Council (NRC) 2001. Assessing the TMDL Approach To Water Quality Management. Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction, Water Science and Technology Board, Division on Earth and Life Studies, National Academy Press, Washington, D.C.

issues have all but paralyzed the regulatory process, wasting tremendous resources on all sides while achieving very little in the way of meaningful improvement in water quality.³

From the Navy perspective maintaining operational readiness and carrying out critical Navy operations while satisfying increasing environmental concerns by regulatory agencies and the Public is severely reducing the Navy's operational flexibility and causing compliance costs to spiral upward. Regulatory agencies, on the other hand, are faced with the challenge of developing and enforcing regulations that protect the environment, allow industry to function, and yet satisfy environmental interest groups. Under the current paradigm, industry has no way to influence the implementation of regulations resulting in increasing frustration and regulatory agencies have no practical model for balancing the various special interests involved in environmental compliance.

To meet this challenge, the Shipyard is working with regulatory agencies and technical stakeholders to develop mutually beneficial and cooperative efforts among stakeholders, pool resources to get better technical data and information, and develop cost efficient and effective compliance strategies at the watershed scale. The Shipyard chose to pursue this pilot project because the Navy believes applying innovative ecological risk assessment tools at the watershed scale will improve TMDL development and result in a more environmentally protective strategy for managing pollutant sources in Sinclair and Dyes Inlets. Understanding and addressing all sources of pollution coming into the Inlets will help regulatory agencies prioritize pollution control and water cleanup plans and focus resources on obtaining measurable improvements in the quality of the environment. Both point and nonpoint pollution sources will be quantified because they will have a direct bearing on setting allowable discharges for industrial activities at the Shipyard. The goal will be to get cleaner water in a more efficient and effective way, provide valuable examples of how to partner with local stakeholders, and determine how to develop innovative, cost-effective solutions to environmental problems, while meeting regulatory requirements.

Overview

The boundaries of the watershed include the receiving waters of Sinclair and Dyes Inlets extending out from the Inlets into the passages that connect them with the main reaches of the

³ Whittemore, R. and G. Ice, 2001. TMDL at the crossroads. *Environmental Science and Technology*, 35:11, pp249a-255a. http://pubs.acs.org/subscribe/journals/esthag-a/35/i11/toc/toc_i11.html

Puget Sound and the surrounding landscape that drains into the Inlets (Figure 1). The watershed scale is the proper scale to address the ecological issues because the issues are a result of the cumulative impacts of multiple interacting sources requiring a “place-based” approach for assessing environmental impacts.

The State of Washington identified Sinclair and Dyes Inlets as being water quality limited because of marine pollutant listings on the [1998 Section 303\(d\)](#) list in sediment, water, fish and shellfish tissue, and fecal coliform listings in tributary streams. The [Federal Clean Water Act, Section 303\(d\)](#) and EPA’s implementing regulations ([40 CFR Part 130](#)) require that states prepare a list of water body segments that do not attain state water quality standards. For each impaired water body on the 303(d) list, Ecology is required to determine the maximum pollutant load the water body can accept and still meet the Water Quality Standards. This Total Maximum Daily Load (TMDL) is then used to develop a Water Cleanup Plan - a strategy to improve water quality in the water body and achieve state standards.

Technical Approach

This technical work master plan identifies the objectives and technical activities that will be implemented during Phase I of the PSNS Project ENVVEST. The technical approach is to develop tools for conducting the assessment and performing specific studies and evaluations to identify relationships among sources of stress and impacts to ecological resources. Technical objectives are defined for the following focus areas (1) Regulatory Studies in support of TMDL development, (2) Modeling Studies, (3) Watershed Studies, and (4) Ecological Studies and Risk Assessment. In addition, core capabilities for data base management, geographic information system (GIS) analyses, and web-enabled project documentation and reporting are defined that will be required for successful implementation of the project.

The general approach for the project is to develop and test a working model for watershed-based assessment and partnering. The approach would build on mutually beneficial and cooperative efforts among stakeholders and agencies by pooling resources to get better products and solve environmental problems. Successful completion would lead to transferring the approach to other Navy activities in Navy Region Northwest as well as the Pacific Fleet, other Navy operational areas, and beyond. Most importantly, other technical stakeholders are joining the project and bringing resources and expertise to the table.

Regulatory studies have been initiated to develop specific TMDLs, define data and information needed to support compliance requirements, and develop alternative regulatory strategies. A strategy for developing specific TMDLs within the study area is being developed that will take advantage of the resources, capabilities, and expertise of the technical team and stakeholders. The development of a TMDL Study Plan for fecal coliform was initiated as the first specific TMDL to be developed and the development of a TMDL to address copper/metals contamination in sediment is the next most likely candidate for TMDL development.

The modeling studies have three thrusts (1) developing a capability to do modeling, (2) applying models to answer specific TMDL, ecological risk, and other regulatory questions, and (3) using calibrated and verified models to conduct scenario simulations. An integrated modeling system is being developed that will include the hydrodynamic and contaminant transport within the receiving waters of the Inlets as well as the surrounding watershed. The modeling studies consist of a series of tasks to develop the integrated modeling capability and conduct specific model applications to support risk analysis, watershed studies, regulatory studies, and respond to stakeholder input. The final modeling product will provide the capability to simulate various risk management and policy alternatives.

Watershed studies are being conducted to define the environmental setting of the landscape, identify sources and volumes of runoff, evaluate the contribution of contaminants and water quality from the landscape, and identify sources of stress and impact on the ecological system. The initial phase of watershed monitoring will establish stations to monitor precipitation and stream flow, collect water quality data of representative streams and storm water outfalls, and assess the ecological condition of selected streams and sensitive habitats.

Ecological risk assessment studies will be conducted to define the components of the ecosystem that are at risk, identify the sources of risk, and ascertain what is required to reduce or manage risk. Ecological risk is the likelihood that ecological impacts are occurring or will occur. The ecological risk assessment process provides a framework for formulating the problem, analyzing exposure and effects data, characterizing risk, and developing effective risk management options.

So far major accomplishments include drafting the strategy for the technical approach; developing a plan for public involvement; conducting ecological studies on benthic flux, water quality assessment, and drogoue trajectories within the Inlets; calibrating and validating a three

dimensional model for simulating tides and currents within the Inlets; setting up transport models for fecal coliform, nutrients/dissolved oxygen, and toxics; and initiating geographic information system (GIS) analysis and watershed monitoring studies for the study area. The current year (January 2002 to December 2002) objectives are to develop study plans for TMDLs in Sinclair and Dyes Inlets; define the scope and implementation of modeling in support of TMDLs; conduct the initial phase of watershed monitoring for the major streams and drainage areas into the receiving waters; initiate a study to estimate sediment mass balance and historical loading of contaminants into the Inlets; calibrate and validate the hydrology component of watershed models and initiate water quality modeling for the major streams (Gorst, Blackjack, Chico, Strawberry, Clear, and Barker) and conduct a model intercalibration study for Anderson Creek; conduct modeling studies on the impact of CSO discharges shellfish beds in Dyes Inlet; and implement the PSNS Project ENVVEST Web/GIS/Database portal to provide access to the project database, GIS layers and shape files, and web-based project management for the PSNS Project ENVVEST.

How to Use This Document

This document has been prepared using embedded hypertext meta-language (HTML) so that sections of the document are linked together and can be navigated by clicking the mouse. When the document is viewed on a computer connected to the Internet, hotlinks provided in the document can be activated to access related pages on the world wide web for online viewing and/or downloading. Through the use of this technology, the document can be used as an entry point to find detailed information about specific aspects of the project, link to background information and supporting documentation on the world wide web, and obtain as little or as much information as desired. Alternatively, the document has been formatted for printing and can be easily printed in parts or as a single document. This document has been issued in draft form to give users and readers the opportunity to submit comments, suggestions, questions, and/or recommendations about the project and solicit input and feedback on the technical approaches and products being developed.

A description of the project, the driving forces, and issues to be addressed are introduced in [Section 1](#). An overview of the project goals and objectives is provided in [Section 2](#) and the organizational and technical working group structure is presented in [Section 3](#). The technical objectives for the work areas are outlined in [Section 4](#), and [tables](#) and [figures](#) are contained in sections 5 and 6. The work breakdown structure and plan of action and major milestones are

charted in [Section 7](#). The current status and progress of the working groups is provided in [Section 8](#), and [Section 9](#) contains a listing of deliverables with links to the products (if available). To provide easy access to background and supporting information, the references in the main body of the text are listed as footnotes. [Section 10](#) provides a complete alphabetical listing of references (and hot links if available), cited in this document. A list of [acronyms and abbreviations](#) and a [glossary of terms](#) are also included in the document.

Summary

To develop and demonstrate alternative strategies for protecting and improving the ecological integrity of Sinclair and Dyes Inlets, PSNS Project ENVVEST is conducting technical studies to support developing TMDLs and assessing ecological risk at the watershed scale. By basing the assessment at the watershed scale environmental problems can be evaluated at the proper scale, an integrating framework for cooperative studies with stakeholders and partners is provided, and linkages between problems and management options can be developed. Technical studies are providing data to address key issues identified by the technical working groups, improving the understanding of how the ecosystem functions, and increasing the ability to solve environmental problems. The technical working groups are fostering partnering among stakeholders and establishing the technical and scientific basis to better protect and improve the health of the watershed.

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Acronyms and Abbreviations

303(d) List	List of waterbodies and stream segments in the state that do not meet water or sediment quality criteria. Also know as “impaired waterbodies”.
ANN	Artificial Neural Network
APL	Applied Physics Laboratory of the University of Washington, Seattle, WA
BKHD	Bremerton Kitsap County Health District
BMSL	Battelle Marine Science Laboratory
CINCPACFLEET	Commander in Charge of the Pacific Fleet
CNO	Chief of Naval Operations
CWG	Community Working Group
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CEAM	Center For Exposure Assessment Modeling
CSO	Combined Sewer Overflow
CTC	Concurrent Technologies Corporation
CWA	Clean Water Act
DIP	Detailed Implementation Plan
DoD	Department of Defense
Ecology	Washington State Department of Ecology
EDXRF	An X-ray fluorescence (XRF) technique used to rapidly measure metals in sediment
EMC	Event Mean Concentration
EML	Event Mass Load
ENVVEST	ENVironmental InVEStment
EPA	United States Environmental Protection Agency
ERDC	Army Corps of Engineers, Engineer Research and Development Center
FPA	Final Project Agreement
FR	Federal Register
GIS	Geographic Information System
HSPF	Hydraulic Simulation Program Fortran
IA	Immunoassay technique used to rapidly measure organic contaminants in sediment
KPUD	Kitsap Public Utilities District
MERC4	Water Analysis and Simulation Program submodel for mercury
NPDES	National Pollution Discharge and Elimination System
NSB	Naval Station Bremerton
NRNW	Navy Region Northwest
POTW	Publicly Owned Treatment Works
PNNL	Pacific Northwest National Laboratory
PSNS	Puget Sound Naval Shipyard
PSP	paralytic shellfish poison (“red tide”)
PRISM	Puget Sound Regional Synthesis Model, University of Washington, Seattle, WA
QA/QC	Quality Assurance/Quality Control
SEP	Superior Environmental Performance
SIP	Stakeholder Involvement Plan
SIS	Summary Implementation Strategy

SSC	Space and Naval Warfare Systems Center, San Diego, CA
SSWM	Surface and Storm Water Management
SWMM	Storm Water Management Model
TBD	To be determined
TWG	Technical Working Group
TMDL	Total Maximum Daily Load
UCI	User Controlled Input file used for HSPF
U.S. EPA	United States Environmental Protection Agency
USN	United States Navy
UW	University of Washington, Seattle, WA
XL	EPA's eXcellence and Leadership Program
WASP	Water Analysis and Simulation Program for Eutrophication -
WASP-Eutro	Water Analysis and Simulation Program for Eutrophication
WASP-Toxi	Water Analysis and Simulation Program for Toxicants -
WDFW	Washington Department of Fish and Wildlife
WDM	Watershed Data Management file used for HSPF
WDOE	Washington State Department of Ecology
WDOH	Washington State Department of Health
WES	Waterways Experiment Station, Vicksburg, MS
WMS	Watershed Management System
www	World Wide Web

1. Introduction

1.1 Project Description

On September 25, 2000, the U.S. Navy Puget Sound Naval Shipyard (PSNS), Region X of the U.S. Environmental Protection Agency (EPA), and the Washington State Department of Ecology (Ecology) signed a Final Project Agreement to initiate Phase I of the PSNS Project ENVironmental InVESTment (ENVVEST).⁴ The PSNS Project ENVVEST is part of [EPA's eXcellence and Leadership Program](#) which was developed to give communities, states and local agencies, federal facilities, and industry the opportunity to propose cleaner, cheaper, and smarter ways of protecting the environment.⁵ The goal of PSNS Project ENVVEST is to create an alternative model for the development and implementation of new environmental regulations. This model will specifically address the development of Total Maximum Daily Loads (TMDL)s for the Sinclair/Dyes Inlet Watershed adjacent to Puget Sound Naval Shipyard (Figure 1).^{6, 7}

The primary motivation for the project is to reduce the impact of environmental regulations on Navy operations and flexibility. While the number of fleet assets and facilities has been steadily declining since the end of the cold war, the cost of complying with environmental requirements has been dramatically increasing. Through PSNS Project ENVVEST, the Navy will have the opportunity to influence the implementation of regulations and improve regulatory efficiency and effectiveness of environmental programs at the Shipyard. The Navy's short-term goal is to partner with Ecology and EPA to develop risk based TMDLs for Sinclair/Dyes Inlet. The long-term goal is to affect a change in the National Pollution Discharge Elimination System regulations.

As defined in the Final Project Agreement,⁶ the PSNS Project ENVVEST consists of two phases. Phase I is designed to develop the technical data and information that will lead to recommendations for alternative regulatory strategies. A procedure for proposing alternative

⁴ Federal Register: October 23, 2000 (Volume 65, Number 205)

⁵ U.S. EPA 2000a. [Project XL: Encouraging Innovation, Delivering Results](#) Office of Policy, Economics, and Innovation, EPA100-K-00-001, September 2000. <http://www.epa.gov/projectxl/xlbooklet.pdf>

⁶ US Navy, U.S. EPA, and Washington State Department of Ecology 2000. Project ENVVEST: [Phase I Final Project Agreement for the Puget Sound Naval Shipyard](#), September 25, 2000 [Federal Register: October 23, 2000 (Volume 65, Number 205)]. <http://www.epa.gov/ProjectXL/puget2/fpassigned.pdf>

⁷ U.S. EPA 2000. [Puget Sound Naval Shipyard Project ENVVEST](#) <http://www.epa.gov/ProjectXL/puget2/index.htm>

strategies will be employed to obtain the endorsement of regulatory agencies, assure the concurrence from stakeholders, and gain public support prior to implementation. Phase II will consist of implementing the approved proposal(s).

1.2 Background

The current regulatory development and implementation process within the Clean Water Act has grown less and less effective as the relative impact of point sources has declined and the impact of non-point sources has increased. Non-point sources are far more difficult to regulate because, by definition, they are not associated with a specific process, or potentially responsible party that can be brought to justice and made to pay for cleaning up the mess. Because everyone is responsible for non-point pollution its regulation is far more complex and contentious.

Currently, regulatory agencies are being required by court order to rapidly produce thousands of TMDLs with little or no new resources.⁸ The regulated community is frustrated by a sense of having reached a point of diminishing returns with respect to their ability to further reduce discharges from their processes. Finally, community stakeholders view the process, the regulatory agencies, and the regulated community with a fair amount of distrust.⁹ Together these issues have all but paralyzed the regulatory process, wasting tremendous resources on all sides while achieving very little in the way of meaningful improvement in water quality.¹⁰

From the Navy perspective maintaining operational readiness and carrying out critical Navy operations while satisfying increasing environmental concerns by regulatory agencies and the Public is severely reducing the Navy's operational flexibility and causing compliance costs to spiral upward. Regulatory agencies, on the other hand, are faced with the challenge of developing and enforcing regulations that protect the environment, allow industry to function, and yet satisfy environmental interest groups. Under the current paradigm, industry has no way to influence the implementation of regulations resulting in increasing frustration and regulatory agencies have no practical model for balancing the various special interests involved in environmental compliance. It is important to recognize that, while PSNS Project ENVVEST is attempting to demonstrate the

⁸ Saltman, T. 2001. Making TMDLs work. *Environment Science and Technology*, 35:11 pp248a-254a.

http://pubs.acs.org/subscribe/journals/esthag-a/35/i11/toc/toc_i11.html

⁹ National Research Council (NRC) 2001. Assessing the TMDL Approach To Water Quality Management. Committee to Assess the Scientific Basis of the Total Maximum Daily Load Approach to Water Pollution Reduction, Water Science and Technology Board, Division on Earth and Life Studies, National Academy Press, Washington, D.C.

¹⁰ Whittemore, R. and G. Ice, 2001. TMDL at the crossroads. *Environmental Science and Technology*, 35:11,

utility of a new model for developing regulatory controls, the need for such a change has been recognized and acknowledged at the highest levels within the regulatory community. In a recent speech at the National Environmental Policy Institute, Christie Whitman, Administrator of the US Environmental Protection Agency said:

“I firmly believe that we have reached a point in our national life where we can come together – stakeholders from every point in the spectrum – to find common ground. America is ready to move beyond the command and control model that has defined Washington’s relationship with the rest of the country on environmental policy.....the ground has shifted – the basic assumptions that drove environmental policies have changed. Now we are ready for a new approach – an approach based on finding common ground to achieve shared goals.”

Remarks of Christie Whitman,
Administrator of the U.S. Environmental Protection
Agency, at the National Environmental Policy
Institute, Washington D.C., March 8, 2001¹¹

To meet this challenge, the Shipyard is working with regulatory agencies and technical stakeholders to develop and test a working model for partnering which seeks to develop mutually beneficial and cooperative efforts among stakeholders, pool resources to get better technical data and information, and develop cost efficient and effective compliance strategies at the watershed scale. The regulatory test case for this project will be the development and implementation of TMDLs within the study area. The TMDL program offers an ideal test bed for this project because of the potential impact of TMDLs on Navy industrial operations, the pre-existing framework for stakeholder involvement, and the extraordinarily high prevalence of litigation and controversy associated with the TMDL process.^{8, 9, 10}

Additionally, the massive, mostly unfunded, new work load imposed on states by court ordered schedules for TMDL development adds both emphasis and urgency for a more efficient process. For example, the State of Washington is required to develop TMDLs for approximately 640 water bodies currently listed as having one or more parameters in non-attainment with federal or state water quality standards by the year 2013 without receiving new funding to complete the

pp249a-255a. http://pubs.acs.org/subscribe/journals/esthag-a/35/i11/toc/toc_i11.html

¹¹ Remarks of Christie Whitman, Administrator of the U.S. Environmental Protection Agency, at the National Environmental Policy Institute, Washington, D.C., March 8, 2001.

http://www.epa.gov/ProjectXL/whitman_03_08_01.htm

effort.¹² Even a model program such as the one run by the Washington State Department of Ecology could not help but be strained to an unhealthy degree by this circumstance.

By addressing environmental concerns at the proper ecological scale, providing an integrating framework for solving environmental problems, and ensuring adequate public involvement, PSNS Project ENVVEST will help in addressing agency concerns, provide data to develop total maximum daily loading for priority constituents, and develop a more efficient and effective means of protecting the environment. Additionally the process of involving other technical stakeholders, local environmental interest groups, and interested community members as partners in the TMDL development process has the effect of demystifying the science and building trust and mutual understanding between these groups. Furthermore, when stakeholders are engaged in the technical studies and involved in developing water cleanup plans, it is much more likely that implementation will be successful.

1.3 Ecological Issues

Protecting the health of the ecological systems within the watershed requires an understanding of what components of the ecosystem are at risk, the sources of risk, and what is required to reduce or manage the risk. Sinclair and Dyes Inlets are listed as “impaired water bodies” by the State of Washington.¹³ Under Section 303(d) of the Clean Water Act, states, territories, and authorized tribes are all required to develop lists of impaired water bodies known as the 303(d) list.¹⁴ The 303(d) list for the Inlets includes listings for heavy metal and organic contaminants in the sediments and tissues of marine organisms, and many stream segments within the watershed are listed for fecal coliforms and/or temperature.¹⁵ The 303(d) listing will require the development of a watershed clean-up plan or Total Maximum Daily Loading (TMDL) to establish limits on pollutants that can be discharged into the water bodies.^{16, 17, 18} Fecal coliform

¹² WDOE 2001a. Water Quality Program Responsiveness Summary Fiscal Year 2001 TMDL Priority List. <http://www.ecy.wa.gov/pubs/0110053.pdf>

¹³ WDOE 1998. [Final 1998 Section 303\(d\) List -WRIA 15.](http://www.ecy.wa.gov/programs/wq/303d/1998/wrias/wria15.pdf)

¹⁴ U.S. EPA 2000. Overview of Current Total Maximum Daily Load - TMDL - Program and Regulations. Office of Water (4503F) EPA841-F-00-009 October 2000, Washington, DC 20460. <http://www.epa.gov/owow/tmdl/overviewfs.html>

¹⁵ WDOE 1998. [Final 1998 Section 303\(d\) List -WRIA 15.](http://www.ecy.wa.gov/programs/wq/303d/1998/wrias/wria15.pdf)

¹⁶ WDOE 1996. [Total Maximum Daily Load Development Guidelines.](http://www.ecy.wa.gov/biblio/97315.html) TMDL Workgroup, Ecology 97-315.

¹⁷ WDOE 1999. [Guidance Document for Developing Total Maximum Daily Loads \(TMDLs\) -- Water Cleanup Plans.](#)

contamination is also an issue in the Inlets. Shellfish beds are closed because of concerns from contamination from Combined Sewer Overflows¹⁹ (CSOs). Currently, the City of Bremerton is constructing major improvements to the sewer system to separate sanitary wastes from storm water.²⁰

Areas of Sinclair and Dyes Inlet have sediments contaminated with heavy metals and toxic organic compounds.²¹ About 30 hazardous waste sites have been identified within the watershed²² and clean up and dredging are currently being conducted by the Navy for areas adjacent to PSNS, Naval Station Bremerton,²³ and the Naval Hospital at Jackson Park.^{24, 25} At the Shipyard, permitted industrial discharges require costly treatment systems,²⁶ yet the industrial discharges only account for a fraction of the loading coming into the Inlet.^{27, 28} Eutrophication is also a concern. Low dissolved oxygen has been observed at head of Sinclair Inlet,^{29, 30} and blooms of algae, red tides, and over abundance of jellyfish are also prevalent. In recent years there has been an increase of shellfish closures due to high levels of paralytic shellfish poison (PSP³¹ also known as "red tide").^{32, 33, 34, 35, 36} In addition, important fish, wildlife, and habitat resources need to be

<http://www.ecy.wa.gov/biblio/9923.html>

¹⁸ WDOE 2001. [Focus: Priority Water Cleanup Plans for Fiscal Year 2001](http://www.ecy.wa.gov/pubs/0010052.pdf). <http://www.ecy.wa.gov/pubs/0010052.pdf>

¹⁹ WDOH 2001. [Office of Food Safety and Shellfish Programs 2000 Annual Inventory: Commercial & Recreational Shellfish Areas of Puget Sound, May 2001](http://www.doh.wa.gov/ehp/sf/Pubs/2000%20Annual%20Inventory.pdf). [http://www.doh.wa.gov/ehp/sf/Pubs/2000 Annual Inventory.pdf](http://www.doh.wa.gov/ehp/sf/Pubs/2000%20Annual%20Inventory.pdf)

²⁰ City of Bremerton, 2000. Cooperative Approach to CSO Reduction. <http://www.cityofbremerton.com/index1.html>

²¹ Long, E.R., J. Hameedi, A. Robertson, M. Dutch, S. Aasen, K. Welch, et al. 2000. Sediment Quality in Puget Sound Year 2 - Central Puget Sound, December 2000. Department of Ecology, Publication Number 00-03-055.

<http://www.ecy.wa.gov/biblio/0003055.html>, see also http://www.ecy.wa.gov/programs/eap/mar_sed/msm_intr.html

²² The Sun 1997. [Toxic Kitsap](http://www.thesunlink.com/packages/toxic/toxic.html). <http://www.thesunlink.com/packages/toxic/toxic.html>

²³ Naval Station Bremerton, Puget Sound Naval Shipyard, Washington Department of Ecology and US EPA (NSB et al.) 2000. Record of Decision for Bremerton Naval Complex, Operable Unit B Marine, Bremerton, WA.

²⁴ Pritchett, L. 1997a. [Living on the remains of an ammo dump](http://www.thesunlink.com/packages/toxic/day3.html). SunLink © 1997 - An online publication of The Sun newspaper of Bremerton, Wash. <http://www.thesunlink.com/packages/toxic/day3.html>

²⁵ Naval Station Bremerton, Naval Hospital Bremerton, Washington Department of Ecology and US EPA (NSB et al.) 2000a. Record of Decision for Jackson Park Housing Complex/Naval Hospital Bremerton, Operable Unit 1, Sites 101, 101-A, 103, and 110, Bremerton, WA.

²⁶ US Navy, US EPA, and Washington State Department of Ecology 2000. Project ENVVEST: [Phase I Final Project Agreement for the Puget Sound Naval Shipyard](http://www.epa.gov/ProjectXL/puget2/fpassigned.pdf), September 25, 2000 [Federal Register: October 23, 2000 (Volume 65, Number 205)]. <http://www.epa.gov/ProjectXL/puget2/fpassigned.pdf>

²⁷ Johnson, H.D., J.G. Grovhoug, and A.O. Valkirs, 1998a. [Copper Loading to U.S. Navy Harbors: Norfolk, VA, Pearl Harbor, HI, and San Diego, CA](http://www.spawar.navy.mil/sti/publications/pubs/td/3052/td3052.pdf). SSC San Diego TD 3052, December 1998. <http://www.spawar.navy.mil/sti/publications/pubs/td/3052/td3052.pdf>

²⁸ Johnson, H.D., J.G. Grovhoug, and A.O. Valkirs. Supplemental 1 to TD 3052. Copper Loading to U.S. Navy Harbors: Bremerton, WA SSC San Diego TD 3052, December 1998b. Please contact lead author for copy of this report <mailto:cjohnson@spawar.navy.mil>

²⁹ Katz et al. 1999. Sinclair Inlet Water Quality Assessment DRAFT. Puget Sound Wastewater Technology and Evaluation Research Project, Space and Naval Warfare Systems Center, San Diego, Ca. September 30, 1999.

³⁰ Albertson, S., J. Newton, L. Eisner, C. Janzen, and S. Bell 1995. 1992 Sinclair and Dyes Inlet Seasonal Monitoring Report. WDOE Environmental Assessment 95-345.

³¹ WDOH 2001b. [Public Health Fact Sheet: Red tide \(paralytic shellfish poisoning\)](http://www.doh.wa.gov/Topics/Red_Tide.htm). Environmental Health Programs Office of Shellfish Programs. http://www.doh.wa.gov/Topics/Red_Tide.htm

³² WDOH 2001. [Marine Biotoxin Bulletin](http://www.doh.wa.gov/Topics/Red_Tide.htm), Environmental Health Programs Office of Shellfish Programs.

protected^{37, 38, 39} and the Endangered Species Act requires protection of endangered or threatened species (e.g. salmon^{40, 41, 42}). A recent evaluation of the health of the Puget Sound compiled by the Puget Sound Action Team indicates improvements in protecting habitat and eliminating sources of contamination and pollution of the Sound, but habitat loss and past contamination continues to threaten the health of the Sound.⁴³

1.4 Execution

The Shipyard chose to pursue this pilot project because the Navy believes applying innovative ecological risk assessment tools at the watershed scale will improve TMDL development and result in a more environmentally protective strategy for managing pollutant sources in Sinclair and Dyes Inlets. Understanding and addressing all sources of pollution coming into the Inlets will help regulatory agencies prioritize pollution control and water cleanup plans and focus resources on obtaining measurable improvements in the quality of the environment. Both point and nonpoint pollution sources will be quantified because they will have a direct bearing on setting allowable discharges for industrial activities at the Shipyard. The goal will be to redirect tax dollars currently spent meeting compliance requirements, to activities that will surpass current regulatory targets and greatly improve the health of the watershed. This technical work master plan defines the goals, objectives, and technical approach planned for the PSNS Project ENVVEST. The technical master plan has been developed to meet the project goals and milestones defined by the ENVVEST Project Management Team. Based on inputs from regulatory requirements, stakeholder involvement, community concerns, and available resources, the Project Management Team will define the ENVVEST goals and milestones and

<http://www.doh.wa.gov/ehp/sf/biotoxin.htm>

³³ WDOH 2001. [Office of Food Safety and Shellfish Programs 2000 Annual Inventory: Commercial & Recreational Shellfish Areas of Puget Sound, May 2001.](http://www.doh.wa.gov/ehp/sf/Pubs/2000) <http://www.doh.wa.gov/ehp/sf/Pubs/2000> Annual Inventory.pdf

³⁴ The Sun 2000. [Red tide forces beach closures.](#) Published in The Sun: 08/25/2000

³⁵ The Sun 2000. [Red tide closes shellfish harvesting at local beaches.](#) Published in The Sun: 06/14/2000.

³⁶ The Sun 2001a. [Red tide problem worsens.](#) Published in The Sun: Aug. 24, 2001.

<http://www.thesunlink.com/news/2001/august/0824redtide.html>

³⁷ Washington Department of Fish and Wildlife (WDFW) 2001. [Priority Habitats and Species.](#)

³⁸ Washington State Department of Natural Resources (WDNR) 2001. [State aquatic lands - managed for all the people of Washington.](#) <http://www.wa.gov/dnr/htdocs/aqr/>

³⁹ WDNR 2001. [Welcome to the Nearshore Habitat Program's Home Page.](#) <http://www.wa.gov/dnr/htdocs/aqr/nshr/>

⁴⁰ Kitsap County 2000. [Salmon Habitat Protection Plan.](#) Natural Resources. <http://www.kitsapgov.com/nr/>

⁴¹ Rideout M, C. W. May, G. Anderson, D. Vandervoort, L. Smith, and K. Folkerts 2000. [Kitsap Peninsula salmonoid refugia study.](#) http://www.kitsapgov.com/download/Refugia_body.pdf

http://www.kitsapgov.com/download/Refugia_Appendices.pdf

⁴² The Sun 2000. [Salmon plan pleases advisory committee.](#) Published in The Sun: 02/27/2000

⁴³ Puget Sound Action Team 2002. [Puget Sound's Health 2002.](#)

approve/endorse the technical master plan to meet the conditions of the Final Project Agreement.⁴⁴

This technical work master plan has been prepared to facilitate and coordinate the interaction of the Technical Working Groups formed to address specific technical work being conducted by the technical team assembled for project by PSNS, EPA, Ecology, and other stakeholders. This technical work master plan will provide information for planning and coordination among the various Technical Working Groups, identify schedules and deliverables, outline the technical approach and technical objectives of specific technical tasks, and define the resources and commitments required for completing project milestones.

A description of the project, the driving forces, and issues to be addressed are introduced in [Section 1](#). An overview of the project goals and objectives is provided in [Section 2](#) and the organizational and technical working group structure is presented in [Section 3](#). The technical objectives for the work areas are outlined in [Section 4](#), and [tables](#) and [figures](#) are contained sections 5 and 6. The work breakdown structure and plan of action and major milestones are charted in [Section 7](#). The current status and progress of the working groups is provided in [Section 8](#), and [Section 9](#) contains a listing of deliverables with links to the products (if available). To provide easy access to background and supporting information, the references in the main body of the text are listed as footnotes. [Section 10](#) provides a complete alphabetical listing of references (and hot links if available), cited in this document. A list of [acronyms and abbreviations](#) and a [glossary of terms](#) are also included in the document.

Major accomplishments included drafting a the strategy for the technical approach being; developing a plan for public involvement; conducting ecological studies on benthic flux, water quality assessment, and drogue trajectories within the Inlets; calibrating and validating a three dimensional model for simulating tides and currents within the Inlets; setting up transport models for fecal coliform, nutrients and dissolved oxygen, and toxics; and initiating GIS and watershed monitoring studies for the study area.

The major objectives during this year (January 2002 to December 2002) are to:

http://www.wa.gov/puget_sound/Publications/pshealth2002/pshealth_index.html

⁴⁴ US Navy, US EPA, and Washington State Department of Ecology 2000. Project ENVVEST: [Phase I Final Project Agreement for the Puget Sound Naval Shipyard](#), September 25, 2000 [Federal Register: October 23, 2000 (Volume 65, Number 205)]. <http://www.epa.gov/ProjectXL/puget2/fpsigned.pdf>

- Develop a study plans and objectives for TMDLs for Sinclair and Dyes Inlets that incorporates problem formulation for an ecological risk assessment and addresses agency, stakeholder, and community environmental concerns within the watershed.
- Define scope and implementation of modeling in support of TMDLs.
- Complete ecological studies on benthic flux, water quality assessment, and drogue trajectories within the Inlets.
- Conduct the initial phase of watershed monitoring for the major streams and drainage areas into the receiving waters.
- Initiate study to estimate sediment mass balance and historical loading of contaminants into the Inlets.
- Calibrate and validate hydrology component of watershed models and initiate water quality modeling for the major streams (Gorst, Blackjack, Chico, Strawberry, Clear, and Barker) and conduct a model intercalibration study for Anderson Creek.
- Conduct modeling studies on the impact of CSO discharges shellfish beds in Dyes Inlet.
- Implement the PSNS ENVVEST Web/GIS/Database Portal to provide access to the NEDS database, GIS layers and shape files, and web-based project management for the PSNS ENVVEST Project.

2. Overview

2.1 Goal

The U.S. Navy's Puget Sound Naval Shipyard (PSNS), U.S Environmental Protection Agency Region X (EPA), and the Washington State Department of Ecology (Ecology) have joined together for an environmental project in Sinclair and Dyes Inlet in the Central Puget Sound. On behalf of the Navy, PSNS has offered to share the data from ENVVEST with EPA, Ecology, other governments, and local agencies and joint goals have been defined for the project.

Navy's Goals for ENVVEST

- Produce the most technically accurate TMDL for Sinclair and Dyes Inlet as possible.
- Partner with agencies to develop a model for cooperative TMDLs that can be used at other Navy facilities and watersheds.
- Help regulatory agencies develop more efficient and effective methods to produce TMDLs and regulate clean water.

Ecology's goals for ENVVEST:

- Address as many 303(d) listed water bodies in the Inlets and watershed as possible.
- Ensure that there is meaningful public involvement in the TMDL process.
- Attain measurable improvements in the water and sediment quality of the estuary and surrounding watershed.

EPA's goals for ENVVEST:

- Develop and apply new and innovative approaches to improve the effectiveness and efficiency of environmental regulations.
- Achieve clean and healthy watersheds that support aquatic life and important human uses.
- Involve community and stakeholders in developing water management plans that meet local needs.

Within the context of the goals for Impaired Water Bodies the project will help ensure that water bodies will meet their beneficial uses (Table 1) under the Clean Water Act (CWA). This

will require the development of a multiparameter, multimedia TMDL for Sinclair and Dyes Inlets, that will meet sediment and water quality targets, address contaminants on the 303(d) list (chemical stressors), and implement Water Cleanup Plans.

Assessing ecological risk at the watershed scale will define the components of the ecosystem at risk and identify the stressors causing risk. Ecological risk assessment is a process to collect, organize, analyze, and present scientific information to improve the use of science in making good management decisions.⁴⁵ “The sound scientific approach of ecological risk assessment can be combined with the watershed approach of using partnerships [with] a geographic and hydrologically based focus ...to enable States, local governments and watershed councils to use the most relevant sound science to prioritize problems and take appropriate actions⁴⁶” and address problems at the watershed-scale.^{47,48} The project will also strive to support other program goals. These include promoting sustainability of endangered and threatened species (salmon) in support of the Endangered Species Act by minimizing take and developing appropriate mitigation strategies; establishing appropriate discharge limits under the National Pollution Discharge and Elimination System (NPDES) Program (waste load allocation); meeting or exceeding cleanup goals developed to protect human health and the environment from past disposal practices under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and maintaining the cleanup levels; establishing appropriate management strategies for storm water; identifying appropriate management strategies for shorelines, and protecting and enhancing natural resources in an appropriate manner.

Successful achievement of these goals will get cleaner water in a more efficient and effective way and result in better TMDLs for the Inlets and watershed. The project will provide valuable examples of how to partner with local stakeholders and how to develop innovative, cost-effective solutions to environmental problems, while meeting regulatory requirements.

⁴⁵ US EPA 1998. Guidelines for Ecological Risk Assessment. Office of Research and Development, Risk Assessment Forum, EPA/630/R-95/002f, May 1998 Washington, D.C. <http://www.epa.gov/ncea/ecorsk.htm>

⁴⁶ Serveiss, V. B., In Press. Applying Ecological Risk Principles to Watershed Assessment and Management. Environ. Management, Accepted. <http://oaspub.epa.gov/eims/eimsapi.detail?deid=23732&partner=ORD-NCEA>

⁴⁷ Cormier, S. and M. Smith. 1996. Big Darby Creek Watershed. USEPA EPA 630/R-96/006A. 14 JUNE 1996. US Environmental Protection Agency, Washington, DC.

<http://oaspub.epa.gov/eims/eimsapi.detail?deid=15201&partner=ORD-NCEA>

⁴⁸ Diamond, J. M. and V. B. Serveiss. In Press. Identifying Sources Of Stress To Native Aquatic Species Using A Watershed Ecological Risk Assessment Framework. Environmental Science & Technology, Accepted.

<http://oaspub.epa.gov/eims/eimsapi.detail?deid=23751&partner=ORD-NCEA>

2.2 Study Area

The boundaries of the watershed include the receiving waters of Sinclair and Dyes Inlets extending out from the Inlets into the passages that connect them with the main reaches of the Puget Sound and the surrounding landscape that drains into the Inlets (Figure 1). The waters of Sinclair and Dyes Inlets are so tightly coupled that it is necessary to model their interaction as one system.⁴⁹ The watershed area that drains into Sinclair and Dyes Inlets consists of 62,348 acres (25,231 hectares) of which about 35% of the watershed is classified as having impervious surfaces. Most of the impervious surfaces are located in the urban centers of Bremerton, Silverdale, and Port Orchard. The stream network drains about 80% of the watershed, but about one third of the impervious surfaces (11% of the watershed) are located in areas not drained by streams (Figure 2). The impervious surfaces that are not drained by streams are urban areas predominantly located in West Bremerton, portions of East Bremerton, and along the shoreline of Dyes Inlet (Figure 2).

The watershed scale is the proper scale to address the ecological issues because the issues are a result of the cumulative impacts of multiple interacting sources requiring a “place-based” approach for assessing risk.^{50, 51} With a watershed-based approach, effects can be evaluated on different scales, hypothesis can be developed and tested, and the proper “environmental management unit[s]” can be defined.⁵² For example, environmental problems at the Shipyard can only be interpreted within the context of Sinclair Inlet, which is inextricably linked by the Port Washington Narrows to Dyes Inlet and through Port Orchard and Rich Passage to the Puget Sound. Problems within the Inlets are related to problems within the receiving water system and the surrounding watershed. Central in this assessment is the idea that the quality of the Inlets is a function of the quality of water draining into the Inlets which is, in turn, a function of the land use and discharge activities that are occurring within the watershed.

⁴⁹ Wang, P.F and K.E. Richter 1999. [A Hydrodynamic Modeling Study Using CH3D for Sinclair Inlet](#), Draft Report. Space and Naval Warfare Systems Center, San Diego, CA, November 3, 1999.

⁵⁰ US EPA 2000b. Workshop Report on Characterizing Ecological Risk at the Watershed Scale. National Center for Environmental Assessment-W, Office of Research and Development, EPA/600/R-99/111, Washington, DC. <http://www.epa.gov/NCEA/pdfs/ecorisk/ecoriskold.pdf>

⁵¹ US EPA 2001b. [Ecological Risk Assessment: Development of guidelines, assessments, and methods that quantify risks to ecosystems from multiple stressors at multiple scales and multiple endpoints.](#) <http://cfpub.epa.gov/ncea/cfm/ecologic.cfm?ActType=default>

⁵² US EPA 2000b. Workshop Report on Characterizing Ecological Risk at the Watershed Scale. National Center for Environmental Assessment-W, Office of Research and Development, EPA/600/R-99/111, Washington, DC. <http://www.epa.gov/NCEA/pdfs/ecorisk/ecoriskold.pdf>

2.3 Historical Setting

A little over hundred years ago, Sinclair Inlet and Kitsap Peninsula were relatively untouched. In 1891, the Puget Sound Navy Yard was established in Sinclair Inlet and the town of Bremerton was founded in 1901 (Table 2).^{53, 54} Rapid development in Bremerton and a boom in the population of Kitsap County followed major expansions at the Shipyard during World War I and World War II. At the height of World War II the population of Bremerton peaked at more than 80,000 people and industrial operations poured out goods for the war effort. Following the end of World War II, work at the Shipyard was reduced, but the Shipyard's workload remained high throughout the cold war and into the 80s and 90s (Table 2). In 1975 the Submarine Base at Bangor was established⁵⁵ and since the late 70s Kitsap County has experienced rapid growth in population, infrastructure, and development of open space (Figure 3).^{56, 57} Currently, about a quarter of a million people live in Kitsap County (Figure 4).

Over the last few decades many studies have been conducted on Sinclair and Dyes Inlets and the surrounding watershed (Table 4). These studies were performed as part of ecological assessment studies conducted by state agencies, remedial investigations and feasibility studies for the clean up of hazardous waste sites.^{58, 59, 60, 61} Other studies have assessed the ecological status and condition of ecological resources within the study area.^{62, 63} These studies represent a body of knowledge that can be drawn on to support the development of water cleanup plans and identify what additional data are needed (data gaps) to complete the assessment process.

⁵³ The Sun 2001b. [Bremerton Centennial 1901-2001: A historical retrospective](http://www.thesunlink.com/bremertoncentennial).

<http://www.thesunlink.com/bremertoncentennial>

⁵⁴ PSNS 2001. [Puget Sound Naval Shipyard History](http://www.psns.navy.mil/history.htm). <http://www.psns.navy.mil/history.htm>

⁵⁵ Horn, Richard 1999. [The Bangor Boom](http://www.thesunlink.com/news/99december/daily/1230a1b.html). By Published in The Sun: 12/30/1999.

<http://www.thesunlink.com/news/99december/daily/1230a1b.html>

⁵⁶ Vandervoort, D. 2001. [GIS analysis for watershed assessment](#). Presentation for the PSNS ENVVEST Modeling Technical Working Group Meeting, Aug 29-30, 2001, Naval Subase Bangor, Wa.

⁵⁷ U.S. Census Bureau 2001. [U.S. Census 2000](http://www.census.gov/dmd/www/2khome.htm). <http://www.census.gov/dmd/www/2khome.htm>

⁵⁸ Naval Station Bremerton, Puget Sound Naval Shipyard, Washington Department of Ecology and US EPA (NSB et al.) 2000. Record of Decision for Bremerton Naval Complex, Operable Unit B Marine, Bremerton, WA.

⁵⁹ Naval Station Bremerton, Naval Hospital Bremerton, Washington Department of Ecology and US EPA (NSB et al.) 2000a. Record of Decision for Jackson Park Housing Complex/Naval Hospital Bremerton, Operable Unit 1, Sites 101, 101-A, 103, and 110, Bremerton, WA.

⁶⁰ Puget Sound Naval Shipyard (PSNS), Naval Station Bremerton, Washington Department of Ecology and US EPA 2000. Proposed plan for cleanup action at operable unit B marine. Bremerton, WA.

⁶¹ URS Greiner Woodward Clyde Federal Services (URS) 2001. Draft final feasibility study report: Operable Unit B, Bremerton Naval Complex, Bremerton, WA, July 23, 2001. Contract No. N62474-89-D-9295 CTO 0131.

⁶² See "Site History" in Naval Station Bremerton, PSNS, Washington Department of Ecology and US EPA (NSB et al.) 2000. Record of Decision for Bremerton Naval Complex, Operable Unit B Marine, Bremerton, WA

⁶³ See also "Kitsap County Initial Basin Assessment Open File References" in Kitsap Public Utilities District (KPUD) 2000. Precipitation, water level, & stream flow data for Kitsap County: Volume I: February 2000, Data

2.4 TMDL Process

2.4.1 Purpose of a TMDL:

The Washington State Department of Ecology (Ecology) is responsible for administering the water quality management program under the authority of state law and under the direction of the Federal Clean Water Act and the U.S. Environmental Protection Agency (EPA). To that end, Ecology has established surface water quality standards to protect the beneficial water uses of the state such as swimming, fishing, aquatic life, and domestic water supply. The water quality standards establish goals for lakes, rivers, and marine waters by assigning appropriate combinations of beneficial uses to each water body, and by setting criteria to ensure those uses are protected. These criteria are often quantitative limits on how much of a particular toxic chemical or other pollutant can exist in a water body without harming the various beneficial uses. Compliance with the surface water quality standards of the state requires compliance with both [Chapter 173-201A WAC](#) (Water Quality Standards) and [Chapter 173-204 WAC](#) (aquatic Sediment Management Standards).

The [Federal Clean Water Act, Section 303\(d\)](#) and EPA's implementing regulations ([40 CFR Part 130](#)) require that states prepare a list of water body segments that do not attain state water quality standards. For each impaired water body on the 303(d) list, Ecology is required to determine the maximum pollutant load the water body can accept and still meet the Water Quality Standards. This Total Maximum Daily Load (TMDL) is then used to develop a Water Cleanup Plan - a strategy to improve water quality in the water body and achieve state standards. The TMDL is a tool for implementing water quality standards and is based on the relationship between in-stream water quality conditions and pollution sources. The allowable pollutant loadings or other quantifiable parameters for a water body are established by TMDLs and thereby provide the basis for establishing water quality-based pollution controls.^{64,65,66}

Coordination with local activities is essential for success in bringing water bodies up to state standards. Ecology hopes to draw the bulk of the TMDL technical studies and

through October 1999. Kitsap Water Resources Monitoring Program.

⁶⁴ Washington State Department of Ecology (WDOE) 1996. [Total Maximum Daily Load Development Guidelines](#). TMDL Workgroup, Ecology 97-315. <http://www.ecy.wa.gov/biblio/97315.html>

⁶⁵ WDOE 2001a. Water Quality Program Responsiveness Summary Fiscal Year 2001 TMDL Priority List. <http://www.ecy.wa.gov/pubs/0110053.pdf>

⁶⁶ WDOE 2001b. [Focus: Priority Water Cleanup Plans for Fiscal Year 2001](#). <http://www.ecy.wa.gov/pubs/0010052.pdf>

implementation activities from ongoing and planned actions in the Sinclair/Dyes watersheds. Furthermore, recognizing the large efforts directed toward salmon recovery under the ESA response, salmon restoration activities and other local actions would be integrated into the development of TMDLs to the extent possible. The Water Cleanup Plan process does not bring new authorities or enforcement powers; rather it relies on existing mechanisms, programs and cooperation with other agencies and tribes to make the process succeed. In the Sinclair and Dyes watersheds, there is a timely opportunity to initiate TMDLs because of numerous water quality related studies, including studies conducted by the Navy, that are currently ongoing.

In the context of PSNS Project ENVVEST, the TMDLs will have at least two scales; one to address water quality issues in the receiving waters of the Inlets, and the other to address water quality issues in individual streams and stream segments. The studies performed under this technical work master plan will provide the basis for setting TMDLs for pollutants that are still being discharged to Sinclair and Dyes Inlets. Based on the results of sampling and analysis, follow on studies may be initiated to address water quality issues in the contributing watersheds. For toxic contaminants in benthic sediments of Sinclair and Dyes Inlets, toxic-contaminant TMDLs should follow the protocols currently being developed for contaminated sediments in Bellingham Bay⁶⁷ and the Duwamish Estuary.^{68, 69} The TMDLs will help establish the level of pollutant reductions necessary to attain water quality standards. Ecological risk assessments and bioassays may be utilized to verify whether standards are being met, prioritize clean-up actions, and target areas at highest risk. By targeting ecologically sensitive areas the approach will result in the greatest gain for local resources.

2.4.2 Background for TMDL Development

The State of Washington identified Sinclair and Dyes Inlets as being water quality limited because of marine pollutant listings on the [1998 Section 303\(d\)](#) list in sediment, water, and fish and shellfish tissue and fecal coliform listings in tributary streams (Table 3). Kitsap Lake near Bremerton is also tributary to Dyes Inlet and is listed for fecal coliform and total phosphorus. The accompanying maps show the locations of marine and fresh water bodies (Figure 5) and the

⁶⁷ Elardo, P. 2001. [Bellingham Bay Contaminated Sediments Total Maximum Daily Load, Review Draft](#). Washington State Department of Ecology, Water Quality Program, 99-58-WQ. <http://www.ecy.wa.gov/biblio/0110036.html>

⁶⁸ Parametrix Inc. 1999. [King County Combined Sewer Overflow Water Quality Assessment for the Duwamish River and Elliott Bay](#). King County Department of Natural Resources, Wastewater Treatment Division & Water and Land Resources Division Seattle, Washington. <http://dnr.metrokc.gov/wlr/waterres/wqa/WQA1.pdf>

⁶⁹ King County 2001. [The Green River Watershed](#) <http://dnr.metrokc.gov/wlr/watersheds/green.htm>

sediment grids and contaminants (Figure 6) on the 1998 Section 303(d) List. Major drainages include Clear Creek, Barker Creek, Blackjack Creek, Annapolis Creek, Anderson Creek, Gorst Creek, Chico Creek, Steele Creek, and Strawberry Creek.⁷⁰ Streams with 303(d) listings include Clear Creek, Barker Creek, Gorst Creek, Blackjack Creek, Beaver Creek, and Olney Creek (also known as Karcher Creek) Creek (Figure 5).

The TMDL for Sinclair and Dyes Inlets should address all significant pollutant sources or stressors, which cause or threaten to cause impairment of the water body, and address contaminants included on the 1998 Section 303(d) or may be added to the 2002 303(d).⁷¹ The assessment must include all point and nonpoint sources, both manmade and naturally occurring. EPA can only approve TMDLs for impaired water bodies (which includes contaminated sediments, fish and shellfish tissue), and therefore, TMDLs or Water Cleanup Plans should be limited to the pollutants and segments listed or otherwise shown to be impaired. Some listings, such as the tissue listings in the Quality Assurance Project Plan for shellfish in Dyes Inlet,⁷² may be taken off the 303(d) list if verification sampling indicates the earlier sampling was in error or the media currently meets standards. In the case of Chico Creek, which did not have any 303(d) listings in 1998, the Navy and Kitsap County are cooperating in developing watershed models, which could be applicable to other impaired watersheds.

2.4.3 Procedure for Preparing TMDLs

Every TMDL or Water Cleanup Plan must include certain essential elements to ensure the result will be complete, acceptable to the public, and approved by EPA.⁷³ These elements include:

- A technical study to identify pollutants causing the water quality problem, the pollutant sources, and the total maximum daily loads for the pollutants.
- Waste load allocations for point sources and load allocations for nonpoint sources that distribute the assimilative capacity of the water body while ensuring it meets

⁷⁰ Kitsap Public Utilities District (KPUD) 2000. Precipitation, water level, & stream flow data for Kitsap County: Volume I: February 2000, Data through October 1999. Kitsap Water Resources Monitoring Program.

⁷¹ WDOE 2001c. 2002 [Section 303\(d\) List Issue Papers](http://www.ecy.wa.gov/programs/wq/303d/2002/issuepprs.html).
<http://www.ecy.wa.gov/programs/wq/303d/2002/issuepprs.html>

⁷² Johnson, A. 2002. [Results of Sampling to Verify 303\(d\) Listings for Chemical Contaminants in Shellfish from Dyes Inlet and Port Washington Narrows](http://www.ecy.wa.gov/biblio/0203011.html). Ecology, Environmental Assessment Program, Olympia, WA.
<http://www.ecy.wa.gov/biblio/0203011.html>

⁷³ WDOE 1996. [Total Maximum Daily Load Development Guidelines](http://www.ecy.wa.gov/biblio/97315.html). TMDL Workgroup, Ecology 97-315.
<http://www.ecy.wa.gov/biblio/97315.html>

water quality standards.

- A margin of safety to ensure that water quality standards will be met under critical conditions.
- An analysis of seasonal variation, where applicable.
- An implementation strategy to identify actions to bring the water body into compliance. The implementation strategy is developed through coordination with local agencies, organizations and community groups.
- Public involvement at all key decisions and steps in the process.

2.4.4 Modeling

Mathematical computer models are critical tools that can be used to develop TMDLs. Models enable scientists to trace pollutants from their source to their environmental fate (dispersion, decay, sedimentation). Once this linkage is established and verified with monitoring data, models can be used to simulate more critical environmental conditions. For example, to predict what water quality might look like in the future when wastewater treatment plants have reached their design capacity, or forested lands have been converted to farms and urban areas. Equally important, models can be used to explore various waste load reduction strategies in order to determine if pollution controls proposed under a TMDL will bring the water back into compliance with state water quality standards.

2.4.5 Implementation

Implementation strategies developed to implement Water Cleanup Plans will be prioritized to address areas of highest risk. The Summary Implementation Strategy (SIS) and Detailed Implementation Plan (DIP) must address all point and nonpoint sources identified in the TMDL and address how their respective waste load allocation and load allocations will be attained. The summary and detailed implementation plans will be developed in cooperation with the Federal, state, local and tribal agencies that have a role in implementing the Water Cleanup Plan. The implementation plans will discuss how water quality standards and allocations will be met over time and discuss the various mechanisms to ensure that point and nonpoint sources will be improved. The implementation plans will include ecorisk information to outline additional goals and actions that may be necessary to achieve desired ecological improvements in sensitive or high priority areas.

Implementation plans will also identify the process by which implementing mechanisms

can change, as new information becomes available. For example, the implementation plans will identify how water quality standards and ecological risk goals will be met over time by identifying specific mechanisms that will be used to ensure improvements, such as point and nonpoint source controls. The plans will identify any long term monitoring needs to assess ecological and water quality gains, be able to identify responsible parties for implementing monitoring and management measures, and identify costs and funding opportunities.

2.4.6 Public Involvement

Public involvement is an integral part of the Water Cleanup Plan process. The Water Cleanup Plan process requires a substantial amount of public involvement in development and implementation, especially where nonpoint sources are dominant in the watersheds. All TMDLs must go through a formal Public Review and Comment process, which includes a 30-day comment period with extensions where appropriate. The Ecology TMDL Lead and Public Involvement Coordinator will facilitate public involvement in developing TMDLs and preparing water cleanup strategies for Sinclair and Dyes Inlet TMDLs. Ecology, along with technical staff involved in conducting the study, will prepare a Responsiveness Summary in response to oral and written comments that will identify where changes were made to the final TMDL.

2.4.7 Administrative Record

The documents, records, meeting notes, and response summaries that were involved in setting the TMDL, will be kept at the local libraries in an accessible, central location during and following development of a TMDL. This documentation constitutes the administrative record for the TMDL and should include:

- Internal peer reviewed draft TMDL
- Copies of internal peer review comments
- Responsiveness summary
- Public Notice information
- Comment record both oral and written
- Submittal letter
- Approval letter
- Final approved TMDL
- Summary and Detailed Implementation Plans

2.5 Ecorisk Process

The components of the ecosystem that are at risk, the sources of risk, and what is required to reduce or manage risk can be determined by conducting a ecological risk assessment. Ecological risk is the likelihood that ecological impacts are occurring or will occur.^{74, 75} The ecological risk assessment process provides a framework for formulating the problem, analyzing exposure and effects data, characterizing risk, and developing effective risk management options^{76, 77} (Figure 7).

Ecological risk assessment requires a firm understanding of the important ecological processes at work within the system (Figure 8). These processes include how water moves from rain to streams and creeks into the tidally dominated estuary (hydrology); the interaction among plants and animals, soils and groundwater, sediments and water column, and the uptake of nutrients and the assimilation of wastes (biogeochemistry); the sources of stress on the natural systems and effects to components of the ecosystem (ecotoxicology); and how components of the system interact (dynamics). From the knowledge of key ecological processes a conceptual model or “picture” of how the system works is developed. The conceptual model provides the basis for formulating the risk assessment and guides the development of specific ecological studies and evaluations needed for the risk assessment. Exposure and Effects Characterization will require data on stressor levels in the environment, the ecological health and condition of ecological resources, and toxicological information from the literature that will help relate exposure levels to ecological effects.

The ecological risk assessment process (Figure 8) will develop the problem formulation (What are the questions being asked?), identify the assessment endpoints (What should be protected?) and exposure pathways (How can ecological resources be harmed?), characterize stress (measure pollution levels), characterize ecological effects (measure toxicity and ecological

⁷⁴ U.S. EPA. 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum, EPA/630/R-92/001, Washington, D.C., 41pp

⁷⁵ US EPA 1998. Guidelines for Ecological Risk Assessment. Office of Research and Development, Risk Assessment Forum, EPA/630/R-95/002f, May 1998 Washington, D.C. <http://www.epa.gov/ncea/ecorsk.htm>

⁷⁶ US EPA 2001b. [Ecological Risk Assessment: Development of guidelines, assessments, and methods that quantify risks to ecosystems from multiple stressors at multiple scales and multiple endpoints.](http://cfpub.epa.gov/ncea/cfm/ecologic.cfm?ActType=default) <http://cfpub.epa.gov/ncea/cfm/ecologic.cfm?ActType=default>

⁷⁷ US EPA 2000e. [Stressor Identification Guidance Document.](#) (EPA 822-B-00-025).

effects), and characterize risk by weighing the lines of evidence and developing conclusions about risk.⁷⁸ The risk assessment will also provide important feedback on the conceptual model and our understanding of how the system works. The conclusions about risk will be used to develop effective risk management and alternative regulatory strategies aimed at reducing or eliminating ecological risk. Follow up monitoring will verify the risk assessment and evaluate the success of alternatives for reducing risk.

2.6 Conceptual Model

The conceptual model identifies the major components and waterborne transport processes of the system (Figure 9) and identifies exposure pathways from sources of stress to the assessment endpoints (Figure 10). Sources of stress enter the system through industrial discharges, outflows from sewage treatment plants, storm water drains, combined sewer overflows, marinas, and streams.

The water quality of the industrial and treatment plant outfalls are a function of the wastewater treatment systems in place and the permissible discharge allowed by NPDES permits. The water quality of the storm water and the streams is a function of the landscape from which the water drains and spills which may enter the drainage system. Once released into the receiving water system, the discharges are mixed and transported by complicated currents that are driven by the tides, winds, and weather events (Figure 9).

Residual contamination within the system from past releases shows up as pockets of contaminated sediments and elevated concentrations of contaminants in the tissues of fish and shellfish. Contaminants in the water column and sediments can come into contact with the pelagic, epibenthic, and benthic communities where they may cause toxicological effects and be accumulated in tissues of organisms. Exposure to food chain receptors such as carnivorous fish, marine mammals, birds, and humans can occur for contaminants that bioaccumulate in the food

<http://www.epa.gov/OST/biocriteria/stressors/stressorid.html>

⁷⁸ Johnston, R.K., W.R. Munns, P.L. Tyler, K. Finkelstein, K. Munney, P. Whittemore, A. Mellivle, and S. Hahn, 2002. Weighing the Evidence of Ecological Risk of Chemical Contamination in the Estuarine Environment Adjacent to the Portsmouth Naval Shipyard, Kittery, Maine, USA. **Environ. Tox. and Chem.** Vol 21, No. 1, pp 182-194.

chain (Figure 10). Currently, major efforts are underway by the Navy to clean up contaminated areas identified near PSNS in Sinclair Inlet^{79, 80} and Jackson Park⁸¹ in Dyes Inlet and by the City of Bremerton to eliminate and control CSO releases in the Port Washington Narrows.⁸²

⁷⁹ Puget Sound Naval Shipyard (PSNS), Naval Station Bremerton, Washington Department of Ecology and US EPA 2000. Proposed plan for cleanup action at operable unit B marine. Bremerton, WA.

⁸⁰ Naval Station Bremerton, Puget Sound Naval Shipyard, Washington Department of Ecology and US EPA (NSB et al.) 2000b. Record of Decision for Bremerton Naval Complex, Operable Unit B Marine, Bremerton, WA.

⁸¹ Naval Station Bremerton, Naval Hospital Bremerton, Washington Department of Ecology and US EPA (NSB et al.) 2000a. Record of Decision for Jackson Park Housing Complex/Naval Hospital Bremerton, Operable Unit 1, Sites 101, 101-A, 103, and 110, Bremerton, WA.

⁸² City of Bremerton, 2000. Cooperative Approach to CSO Reduction. <http://www.cityofbremerton.com/index1.html>

3. Technical Working Groups

This technical work master plan identifies the objectives and technical activities that will be implemented during Phase I of the PSNS Project ENVVEST. The technical approach is to develop tools for conducting the assessment and performing specific studies and evaluations to identify relationships among sources of stress and impacts to ecological resources.⁸³ Technical objectives are defined for the following focus areas (1) Regulatory Studies in support of TMDL development, (2) Modeling Studies, (3) Watershed Studies, and (4) Ecological Studies and Risk Assessment. In addition, core capabilities for data base management, geographic information system (GIS) analyses, and web-enabled project documentation and reporting are defined that will be required for successful implementation of the project.

The project management structure for the PSNS Project ENVVEST consists of the Project Management Team, a Technical Steering Committee, and Technical Working Groups formed to address specific technical areas and issues (Figure 11). The project management team consists of one representative from each of the signatory agencies. The role of the Project Management Team is to guide project development through both Phase I and II of the ENVVEST/XL project. The Technical Steering Committee is comprised of the technical leads from PSNS, EPA, and Ecology. The Technical Steering Committee will oversee the development of the technical work master plan and will assure that it will meet the goals and objectives defined by the Project Management Team. The Technical Steering Committee will periodically review and update the technical work master plan, identify issues and concerns that need to be addressed by the Project Management Team, assist with reviewing and interpreting technical results, and evaluate the implications of technical accomplishments in meeting project goals, milestones, and objectives. The Technical Steering Committee will also provide technical direction and guidance to the Technical Working Groups in conducting specific technical tasks.

In concert with the project copartners and stakeholders, the Navy will produce technical studies, some of which will provide the basis for TMDLs. The technical studies should characterize water quality of the listed water body and should identify the various point and

⁸³ US EPA 2000e. [Stressor Identification Guidance Document](http://www.epa.gov/OST/biocriteria/stressors/stressorid.html). (EPA 822-B-00-025).
<http://www.epa.gov/OST/biocriteria/stressors/stressorid.html>

nonpoint pollutant sources. Where appropriate, Ecology will use these studies to engage public involvement and develop TMDLs on the water bodies studied. EPA's role is to ensure TMDLs and the associated submittal reports meet the statutory requirements and approve the Water Cleanup Plans. If a water body is not impaired, or is impaired by a non-pollutant, Ecology can still establish a TMDL on the water body but it will not be subject to approval by EPA.

The Technical Working Groups will be developed on an *ad hoc* basis to address specific technical issues for the project. The signatory agencies will provide resources and personnel to form the Technical Team to conduct the studies and assessments outlined in this plan. The Technical Team is made up of the performing laboratories that are under contract or otherwise tasked by the Navy, EPA, or Ecology to conduct work in support of Project ENVVEST. The Technical Working Groups are made up of representatives of the Technical Team and technical representatives of stakeholders and agencies who have an interest or stake in the technical issues being addressed. The Technical Working Groups will assist the Technical Team in conducting data gathering and analysis activities to develop the technical data and information needed for the project. The Technical Working Groups will provide a forum for evaluating, recommending, and documenting technical decisions and plans, appraising the status and direction of the work, and helping develop a consensus on technical issues. Periodic Technical Working Group meetings will be held to evaluate the technical progress and status of the project, refine technical goals and objectives, and coordinate planning and execution of technical work. Current Technical Working Groups and Subworking Groups include ([See Section 8](#)):

[Regulatory/Ecorisk Working Group](#)

[TMDL Subworking Group](#)

[Modeling/Watershed Assessment Working Group](#)

[Watershed Modeling Subworking Group](#)

[CSO Modeling Subworking Group](#)

Results and information developed by the Technical Working Groups will also be presented and made available to the [Community Working Group](#). The PSNS Project ENVVEST Community Working Group has been formed to provide a forum to foster openness and trust, convey information about the project to the community, identify community concerns, obtain a diversity of viewpoints, and provide feedback on proposed decisions. The Community Working Group will meet periodically to discuss progress and status of the project, represent community interests, and weigh in on issues of concern to the community.

3.1 Technical Team

Organization	Project Tasking (Current Year Execution)
Army Corps of Engineers, Engineer Research and Development Center (ERDC): Coastal and Hydraulics Laboratory and Environmental Laboratory at the Waterways Experiment Station (WES), Vicksburg, MS	The ERDC will calibrate and verify HSPF models for Gorst, Blackjack, and Anderson Creeks, and provide oversight and coordination for all watershed modeling conducted for the project. WES is the national leader in the development and application of watershed models. Because they have developed many of EPA's watershed modeling programs they have outstanding credibility with both regulators and the public at large.
Pacific Northwest National Laboratory's (PNNL) Battelle Marine Science Laboratory (BMSL)	BMSL will provide technical expertise to develop and execute a study to determine the inventory of contaminants in the sediments of the Inlets, identify the present sources of the contaminants, and estimate the rate of natural recovery of contaminated sediment. BMSL specializes in the development of specialized methods for detection, analysis, interaction, and degradation of potentially toxic and hazardous chemicals in the marine environment, with emphasis on the detection of ultra-low levels of environmental contaminants, chemical speciation of metals, analytical methods development, and the chemical fate and role of contaminants in the ecosystem.
Concurrent Technologies Corporation (CTC)	CTC will provide technical support and assistance in providing modeling and technical information support for PSNS Project ENVVEST. With funding from the Navy, CTC has developed the Northwest Environmental Database Systems (NEDS) and specifications for implementing a portal to support database, GIS, and web-based project management for PSNS Project ENVVEST.
Kitsap Public Utilities District (KPUD)	The KPUD will conduct stream gage and rain gage monitoring on selected streams in Kitsap County and assist in sample collection for stream water quality monitoring. KPUD provides technical expertise to conduct stream gage monitoring, calculate ratings for the streams, and perform meteorological observations of importance to the PSNS Project ENVVEST.
Navy Region Northwest (NRNW)	NRNW will assist PSNS with contract management of work performed under the GSA contract and provide coordination for the transition of ENVVEST technologies to other Navy Activities in NRNW.
Puget Sound Naval Shipyard (PSNS)	PSNS will provide oversight and coordination for all activities conducted for Project ENVVEST. PSNS will participate in the ENVVEST Program Management Team, the ENVVEST Technical Steering Committee, and Technical Working Groups,

coordinating and planning community outreach activities, developing partnerships with technical stakeholders and other agencies, and conduct other program management activities.

Space and Naval Warfare
Systems Center (SSC)

SSC will provide technical support and assistance for watershed-based ecological risk assessment and TMDL development, calibrate and verify HSPF models for Strawberry, Clear, Barker, and Anderson Creeks, conduct CH3D and WASP modeling in support of TMDL development and other applications (CSO impact on Dyes Inlet), apply rapid assessment techniques in support of developing a contaminant mass balance for sediment, and provide technical support for developing the TMDL study plan. SSC is the Navy's lead laboratory for the development and implementation of environmental science and technology to support environmental requirements at Navy facilities. This includes modeling hydrodynamic transport of environmental contaminants, developing new and innovative sensors and sampling methodologies, assessing ecological risk, developing effective compliance strategies, and providing scientific and technical environmental protection compliance assistance to the United States Navy.

University of Washington,
Applied Physics Laboratory
(UW APL)

UW APL will provide technical expertise for stream ecology and conducting watershed monitoring. UW APL specializes in watershed analysis and urban stream ecology, salmonid habitat assessment and restoration, and the application of best management practices for storm water.

Other Subcontractors

Specific subcontract(s) will be developed to provide analytical chemistry analysis of watershed monitoring samples and other support services required for Project ENVVEST.

Washington State
Department of Ecology
(Ecology), Northwest
Regional Office,
Environmental Assessment
Program.

The Ecology TMDL Lead and Public Involvement Coordinator will facilitate public involvement in developing TMDLs and preparing water cleanup strategies. Technical staff from the Environmental Assessment Program will participate in the working groups and assist the Technical Team in developing and executing studies that will meet TMDL requirements.

U.S. Environmental
Protection Agency (EPA),
Region X, Office of Research
and Development

EPA will provide technical input and guidance to ensure TMDLs and the associated submittal reports meet the statutory requirements and review and approve the Water Cleanup Plans; ensure the public involvement of community and stakeholders in developing water management plans that will effectively meet local needs; integrate across programs to achieve clean and healthy watersheds; and provide liaison between EPA's Office of Research and Development to link EPA technical staff with the Technical Working Groups and participate in the working groups.

3.2 Technical Stakeholders

The Technical Working Groups are open to technical representatives of organizations or agencies that have an interest or stake in the technical issues and questions being addressed.

Organization	Contribution (Current Execution Year)
City of Bremerton	Participation in Technical Working Groups, especially CSO modeling study. Collaboration on data collection and analysis for model calibration and verification and assistance in TMDL development. Assistance with public involvement and outreach.
Kitsap County, Natural Resources, Surface and Storm Water Management	Participation in Technical Working Groups, especially watershed modeling and monitoring. Collaboration on Chico Watershed Futures project, watershed monitoring, data collection and analysis for model calibration, and verification and assistance in TMDL development. Coordination on salmon restoration and management. Assistance with public involvement and outreach, coordination for participation by community members.
Suquamish Tribe	Participation in Technical Working Groups, especially CSO modeling study. Collaboration on field data collection and analysis for model calibration and verification and assistance in logistics. Data sharing on natural resources (shellfisheries) and ambient monitoring for fecal coliform. Coordination on salmon restoration and management.
Washington State Department of Health (DOH)	Participation in Technical Working Groups, especially CSO modeling study. Collaboration on field data collection and analysis for model calibration and verification and assistance in logistics. Data sharing on natural resources (shellfisheries) and ambient monitoring for fecal coliform.
Bremerton Kitsap County Health District (BKHD)	Participation in Technical Working Groups, especially CSO modeling study. Collaboration on data collection and analysis for model calibration and verification and assistance in TMDL development. Assistance with monitoring streams and marine waters.
University of Washington, Puget Sound Regional Synthesis Model (PRISM), Sea Grant	Collaborate with PRISM on modeling studies for Puget Sound circulation, atmospheric modeling, and ecological assessments. Coordinate with Sea Grant on public outreach and educational opportunities for community members.
Others TBD	

4. Technical Objectives

This section defines the technical objectives, outlines the technical approach, and defines the products, deliverables and recommended schedule to be implemented. Depending on the technical task, project-specific work plans will be developed by the performing laboratory(ies) to document the procedures, methods, and QA/QC measures required to complete the task.

4.1 Regulatory Studies

Regulatory studies have been initiated to develop specific TMDLs, define data and information needed to support compliance requirements, and develop alternative regulatory strategies. A strategy for developing specific TMDLs within the study area is being developed that will take advantage of the resources, capabilities, and expertise of the ENVVEST technical team and stakeholders. The development of a TMDL Study Plan for fecal coliform was initiated as the first specific TMDL to be developed and the development of a TMDL to address copper/metals contamination in sediment would probably be the next most likely candidate for TMDL development.

4.1.1 TMDL Development

4.1.1.1 Background – General TMDL Strategy

Total Maximum Daily Loads (TMDLs) are established as a response to threatening contaminant (pollutant) concentrations or degraded environmental conditions (pollution). When pollutants/pollution in a water body have been found that exceed criteria or narrative guidelines, the local aquatic environment is included on the [Section 303\(d\)](#)⁸⁴ list. Contaminants in fish and shellfish (either measured or extrapolated from EPA bioaccumulation factors) that pose a human risk via consumption can also result in a [Section 303\(d\)](#) listing.

Sinclair and Dyes Inlets are listed on the Section 303(d) list for high fecal coliform concentrations, and high contaminant (pollutant) concentrations in sediments, fish and shellfish tissue. Eutrophication and subsequent low oxygen levels, due to benthic oxygen demand, are suspected but do not presently warrant listing. Concentrations of toxic chemicals must meet

⁸⁴ WDOE 1998. [Final 1998 Section 303\(d\) List -WRIA 15](#).
<http://www.ecy.wa.gov/programs/wq/303d/1998/wrias/wria15.pdf>

Washington's marine water quality standards (listed in [WAC 173-201A-040](#))⁸⁵ and marine sediment concentrations (listed in [WAC 173-204-320](#))⁸⁶ and toxics criteria in 57 Federal Register (FR) 60922 applicable to Washington State. In particular, Sinclair and Dyes Inlet must meet water quality standards for fecal coliform (14 cells/100 ml), dissolved oxygen (6 mg/l) temperature and pH standards since they are designated Class A (excellent) beneficial use ([WAC 173-201A-130](#))⁸⁷. Beneficial uses of a Class A water body include domestic water supply; salmonid migration, rearing, spawning, and harvesting; fish and shellfish harvesting, excellent wildlife habitat, and primary human recreational contact ([WAC 173-201A-030](#))⁸⁸. The designated beneficial use is also protective for local terrestrial organisms and humans as well.

In order to complete TMDL calculations, it is necessary to (1) determine point and non-point sources contributing to pollutant loads (2) establish load allocations which meet water quality based standards.

4.1.1.2 Rationale for TMDL Approach:

Problem Statement: Pollution problems are impairing beneficial uses of water bodies in Sinclair and Dyes Inlet and the surrounding watershed. The need to assure beneficial uses of marine waters provides a basis for developing a TMDL. In other words, calculating a TMDL will help develop a strategy for achieving beneficial uses of water bodies in the study area. Based on the Section 303(d) listings and other ecological issues (see [Section 1.3](#)) toxics (metals and organic contaminants), fecal coliforms, eutrophication, and habitat degradation are impairing beneficial uses within the watershed. The target levels that will assure beneficial uses are defined by Water Quality Criteria (numerical standards, see [WAC 173-201A-130](#)), Sediment Quality Criteria (numerical and biological standards, see [WAC 173-204-320](#)), tissue residues (narrative criteria⁸⁹,⁹⁰), and improvements in the health of ecological resources (i.e. ecorisk). To determine how bad

⁸⁵ Washington State 1997. [Chapter 173-201A WAC, Water Quality Standards For Surface Waters Of The State Of Washington](#). <http://www.ecy.wa.gov/biblio/wac173201a.html>

⁸⁶ Washington State 1995. [Chapter 173-204 WAC SEDIMENT MANAGEMENT STANDARDS](#). <http://www.ecy.wa.gov/pubs/wac173204/index.html>

⁸⁷ Washington State 1997. WAC 173-201A-140 Specific classifications -- Marine water. <http://search.leg.wa.gov/wslwac/WAC%20173%20%20TITLE/WAC%20173%20-201A%20CHAPTER/WAC%20173%20-201A-140.htm>

⁸⁸ Washington State 1997. WAC 173-201A-030 General water use and criteria classes. <http://search.leg.wa.gov/wslwac/WAC%20173%20%20TITLE/WAC%20173%20-201A%20CHAPTER/WAC%20173%20-201A-030.htm>

⁸⁹ U. S. Food and Drug Administration (FDA) 2001. [Seafood Information and Resources](#), Center for Food Safety and Applied Nutrition, Oct 25, 2001. <http://vm.cfsan.fda.gov/seafood1.html>

⁹⁰ US EPA 2001. [National Fish and Wildlife Contamination Program](#), Office of Water, Oct 25, 2001. <http://www.epa.gov/waterscience/fish/>

the problem is, the difference between the standard and current situation needs to be summarized.

The next step is to determine the loading terms for contaminants from the streams, storm water, point sources, and nonpoint sources within the watershed. The boundary conditions with Central Puget Sound need to be estimated and fluvial deposits associated with stream and storm water drainage need to be assessed to develop a record of inputs, determine if there are any unidentified stressors, and evaluate potential sources.

Modeling studies will assess the assimilative capacity of the receiving waters by determining how much contamination can be released into the system without exceeding the standards or criteria. In addition, sediment deposition rates will be determined and the record of contaminant inputs into the system will be examined to assess pollution trends in the estuary. The bioaccumulation of contaminants in the food chain and current status and inventory of chemical levels and their effects will also need to be assessed.

The TMDL portion of Project ENVVEST involves two relatively independent modeling and measuring efforts, coupled by a primarily measuring effort. These efforts may proceed in parallel but must eventually be coupled to predict the impact of contaminant loads on water, sediment and tissue quality, and ultimately predict TMDLs. They are:

(1) Watershed and urban catchment modeling: This effort involves collecting pertinent watershed data (rainfall, stream flow, slope, groundcover, porosity, land use, storm water drain layout, etc.) and developing models that predict storm water and baseline flow as a function of rainfall. The HSPF model will be used for watersheds and the Storm Water Management Model (SWMM) will be used for urban storm water runoff.

(2) Receiving water modeling: Developing hydrodynamic and contaminant transport and fate models for the receiving waters of Sinclair and Dyes Inlets.

4.1.1.2.1 Water Quality Modeling:

There are several ways in which models can predict contaminant loads. Watershed and urban storm water catchment models can predict water flow into the receiving water body, and to some extent predict contaminant load. In lieu of models, field measurements alone can be used for gross calculations to estimate allowable loads. For watershed models in general, field measurements of contaminant concentrations are particularly crucial since the models usually do not predict them. Site-specific measurements, or broad empirical relationships of contaminants

and land use (e.g. 1983 National Urban Runoff Program US. EPA 1983) can characterize typical contaminant concentrations, which when multiplied by flow, yield contaminant load. Watershed model rainfall simulations will then use the same measured concentrations to simulate subsequent contaminant loads.

Data on contaminant loading from the watershed will need to be collected. This effort involves collating historical load data, measuring current loading, comparing loading to land use in specific watersheds and catchments, and making this data available to the modeling efforts. Ideally, load data would include contaminants in the dissolved and particulate fractions and the size distribution of the particulate load. These data would be needed to predict the hydrodynamic transport of contaminants entering the inlets. The current strategy calls for measurements of summer and winter baseline flows, as well as event-averaged flows resulting from winter storms.

Model simulations will predict daily loads that will meet water quality standards in some period of time. The load predictions will most likely be site-specific around the perimeter of the water bodies, being less in stagnant regions and greater in better-flushed regions. Implementing the recommended loads (management goals) or prioritizing the contaminants in terms of impact (management options) is primarily the responsibility of regulatory agencies.

If post-model monitoring is used to determine the efficacy of the model predictions, the same monitoring framework might be used to determine whether load limits are being met – particularly at point sources.

4.1.1.2.2 Sediment Contamination Modeling:

Contaminated sediment can act as a source of pollutants that may affect the health of marine life. Since contaminants can flux from sediment to the overlying water column and/or aquatic food chains, contaminated sediment is considered a pollutant source requiring a load allocation. In addition sediment contamination will be addressed as an exposure route for the ecological risk assessment.

4.1.1.2.3 Model Development for TMDL

This effort involves collecting water velocity, water density, tidal height, sediment deposition and sediment mixing rates and developing transport models (Curvilinear Hydrodynamics in 3 dimensions - CH3D) and water and sediment quality models (Water

Analysis and Simulation Program⁹¹ for Eutrophication - WASP-Eutro, for Toxicants - WASP-Toxi, and the WASP submodel for mercury - MERC4). The models predict where contaminants entering Sinclair and Dyes Inlets will go and how they will be transformed. These models will be primarily responsible for calculating TMDLs. Data on water quality and benthic flux have been collected in this effort as well. TMDL calculations will involve models that are calibrated and validated with independent sets of field measurements. Degradation and transformation assumptions can be incorporated in the model for both water column and sediment. For the water column, this includes dilution and flushing into a larger, less polluted sink (e.g. Puget Sound). The rate of loss at this boundary depends on the concentration gradient, hence the need to establish contaminant boundary conditions. For the sediment, contaminant loss includes burial to an abiotic depth and flushing through sediment resuspension and transport. For both matrices, loss terms include contaminant degradation or transformation to less bioavailable or toxic forms. Contaminant transport models for the water column and sediment bed can be developed that include these specific loss assumptions. Water and sediment quality models can then be combined with transport models that, by including degradation and transformation processes, predict contaminant fate.

The boundaries with the Puget Sound could conceivably serve as contaminant sources, but most likely as sinks. The flux of contaminants from the sediments will have to be accounted for or estimated. Loss rates and mixing will be measured and modeled in the water column and sediment. Sediment core data will provide measurements of the burial rate, mixing rate, depth of the biotic zone in sediments and historical loading. Resuspension of sediments and transport out of the water bodies could be modeled stochastically, but currently there is no plan on measuring this loss term. Once contaminants are adsorbed to sediments in the bed, they will be treated as staying in place.

4.1.1.2.4 Reaching Water Quality Targets

Once the models have been calibrated and verified they will be used to predict whether current loading will exceed water quality targets. Possible management alternatives will be simulated by the models to assess the efficacy of risk management options and prioritize implementation goals. The strategy for implementing TMDLs is to assess what needs to be done, evaluate the best mix of skills and abilities that can be brought to bear on the problem, and

⁹¹ US EPA CEAM 2001. U.S. EPA Center For Exposure Assessment Modeling: WASP.
<http://www.epa.gov/ceampubl/wasp.htm>

determine what can be accomplished. The implementation plan will also consider other alternatives/approaches and state why they were ruled out (see Section 2.4.5 above).

4.1.1.2.5 Evaluating TMDL Performance

Once the Water Clean up Plan(s) is(are) implemented, it will be necessary to evaluate how well the system will recover (i.e. are things getting better?). Long term monitoring and follow up studies will be required to assess the success of the clean up strategies. The results from the ecorisk assessment can identify whether risk is being reduced and improvements in ecological indicators will determine if ecological health is improving.

4.1.1.2.6 Other Considerations:

Budget constraints will probably limit the location and frequency of monitoring that will be undertaken by the Navy. Ecology, EPA or other local stakeholders may collect additional data. Site-specific load versus land use relationships derived from concentration measurements can be used to extrapolate loads for those modeled watersheds and catchment basins where the land use is known. Examining previously collected concentration data (e.g. NPDES measurements) can be used for this extrapolation as well, resulting in a preliminary ranked list of the most important load points for the NPDES-measured contaminants. Models will predict concentrations resulting from input and loss rates and mixing times. Input terms will be adjusted so that resulting concentrations approach water quality standards within a reasonable time frame. Again, the important existing input rates will be measured, though budget constraints will force some extrapolation based on land use.

Once calculated loads are implemented through regulatory action, subsequent monitoring of water, sediment and tissue quality should be undertaken to determine whether model predictions were correct.

These measurement endpoints may not be the real assessment endpoints one desires to protect. Follow-up monitoring can be recast into a more formal risk assessment where higher trophic levels and habitat quality are monitored as well.

The current inventory of contaminants on the Section 303(d) list may not be complete, either in the contaminants identified in Sinclair and Dyes Inlets or in their distribution in the sediments. This shortfall can be addressed by measuring an expanded list of contaminants at the selected measurement locations. In addition, sediment screening techniques involving Xray

fluorescence (metals), UV fluorescence (PAHs) and antibody activity (chlorinated organics) will be used to screen for a wide range of contaminants. The screening approach will help fill in data gaps but detection levels and the contaminants that can be quantified by the screening methods will limit the screening results.

4.1.1.3 TMDL Products

The scope for developing a Water Cleanup Plan for the Watershed will be developed according to current State of Washington Department of Ecology Guidance:⁹²

“A Water Cleanup Plan, or TMDL, is a common-sense, science-based approach to cleaning up polluted water so that it meets approved water quality standards. TMDLs involve an initial assessment of the water quality problems, a technical analysis to determine how much pollution must be reduced to protect the water, the selection and implementation of appropriate control measures, and follow-up monitoring to determine the success of the complete effort.

Certain essential elements must be included in every TMDL to ensure that the resulting plan will be complete, be acceptable to the public, and be approved by EPA. These elements are:

A technical study identifying the pollutants causing the water quality problem and the sources of those pollutants.

A wasteload or load allocation for pollutants that distribute allowable levels of pollution among contributing sources.

A margin of safety to ensure water quality standards will be met under the worst conditions likely to be experienced.

A Seasonal Variation.(WQ standards must be met during all seasons of the year)

An implementation plan to clean up excess pollution.

A follow-up monitoring plan to demonstrate success of pollution controls contained in the implementation plan or the need for additional action.

Public involvement at all key decision steps of the process. Special attention must be given to federally-recognized tribes who have treaty interest in the watershed and tribes with

⁹² WDOE 1999a. [Guidance Document for Developing Total Maximum Daily Loads \(TMDLs\) -- Water Cleanup Plans](http://www.ecy.wa.gov/biblio/9923.html). <http://www.ecy.wa.gov/biblio/9923.html>

federally-approved water quality standards.”⁹²

EPA and Ecology will have the lead in developing the necessary TMDL documentation.

4.1.1.3.1 TMDL Scope

4.1.1.3.2 TMDL Technical Study

4.1.1.3.3 Waste Load and Load Allocation

4.1.1.3.4 Implementation Plan

4.1.1.3.5 Monitoring Plan

4.1.1.4 Strategy for Developing Specific TMDLs

During the [March 29, 2002 technical focus meeting between PSNS, EPA and Ecology](#) a strategy for developing specific TMDLs within the study area was developed. Based on the current and anticipated 303(d) listings within the ENVVEST study area (see Figure 6, Table 3) groupings of listings were proposed that could be packaged as specific TMDLs. A schedule for studies to address these specific TMDLs could be developed that will take advantage of the resources, capabilities, and expertise of the ENVVEST technical team and stakeholders (see table below). Priorities in table refer to potential for early TMDL development and success—for example, toxics in tissue listing is “low” because Ecology has never done one. The development of a TMDL Study Plan for fecal coliform was initiated as the first specific TMDL to be developed. A fecal coliform TMDL study plan was selected as the pilot project because it is only one-parameter and the various pieces—background (what’s known); what needs to be done to finish (gap analysis); monitoring plan; model/loadings; schedule/budget/organization; QA/QC/procedures are readily available. The development of a TMDL to address copper/metals contamination in sediment would probably be the next most likely candidate for TMDL development. A TMDL to address copper/metal sediment contamination would address the majority of 303(d) listing, is of great interest to the Navy, and would draw on the considerable resources and expertise available through ENVVEST to work on the project.

Based on the consensus of the meeting, the project team will focus on developing and executing a TMDL Study Plan for fecal coliform in the short term, and then focus on developing TMDL study plan(s) for copper and metals to be executed in fiscal year 2003 (starting in October 2002). A TMDL scoping document would need to be developed that would present the rationale and approach outlined in the table below, conduct the analysis of which chemicals, if any, should be delisted, develop a schedule for study design development and execution, and incorporate stakeholder and public involvement.

Sinclair-Dyes Inlets 303d listings and proposed actions.			
Priority	303d listings	Proposed action	Rationale
H	Fecal coliform in Sinclair-Dyes inlets (3)	TMDL pilot study	High stakeholder interest, less complexity than toxics TMDLs
H	Fecal coliform in Clear Creek (7)	Possible add-on to TMDL pilot	Bangor sub base part of drainage
H	Sinclair Inlet sediment toxicity, grid F1 (1+10)	Bioassay verification sampling	Note – likely will be 10 toxic chemical listings added to this grid in '02
M	Toxics in Sinclair Inlet sediment, grids F3 + F4 (30)	TMDL packaging per B'ham Bay	Remediation complete, source control nearly complete
M	Toxics in Sinclair Inlet sediment (40)	Remediation/TMDL study (include grid F1 if needed)	Ecology review of recent sediment chemistry data indicates 6 new grids may be listed in '02
M	Dissolved oxygen in Sinclair Inlet (1)	TMDL study	Will be added to 303d list in '02
L	PAH in Oyster Bay and Port WA Narrows shellfish (2)	Likely 1 delisting but 4 new PAH listings in '02; await Ecology report rec's	Verification sampling completed by Ecology
L	Arsenic in Sinclair-Dyes-Port Orchard fish, shellfish (11)	Await results of Ecology arsenic speciation study	Arsenic likely to be naturally high in marine water/tissue
L	PCBs in Sinclair Inlet fish & shellfish, grid F3 (2)	Monitor for PCB reductions in mussel & sole	Sediment remediation and source control nearly complete
-	Pesticides in Sinclair Inlet fish (2)	Delist in '02	Verification sampling completed by Ecology
-	Toxics in Ostrich Bay sediment (6)	TMDL packaging after cleanup	Remediation in planning stage
-	Toxics in Ostrich Bay shellfish (9)	Delist all but mercury in '02; await sediment remediation to see if mercury levels in crab decline	Verification sampling completed by Ecology

4.1.2 Regulatory Framework

The existing regulatory framework for the watershed will be reviewed to identify data and information needed to support compliance requirements and develop alternative regulatory strategies. Review report documenting and detailing the regulatory framework of the watershed will be prepared. The report will identify and document data available for the Sinclair/Dyes Inlet area from all potential data sources. This will include documentation of (a) the entity collecting the data, (b) their purpose for collecting the data, and (c) where the data are located. A preliminary quality assessment of the data and a general explanation of how the data are being used by the collecting entity will be developed. Maps will be created to show the spatial coverage of the sampling points for each data source. An accompanying table will provide information about the data (metadata) and links of where to obtain more information. A web-based regulatory information clearinghouse with links to regulatory programs, points of contact, and information sources will also be prepared. A case study report will also be prepared to document the development and implementation of TMDLs in the State of Washington. The report will provide lessons learned on how to conduct TMDL studies and obtain improvements in environmental quality.

4.1.2.1 Regulatory Framework Products

4.1.2.1.1 Framework Report

4.1.2.1.2 Information Clearing House

4.1.2.1.3 TMDL Case Study Report

4.1.3 Alternative Regulatory Strategies

Following the process outlined in the Final Project Agreement alternative strategies will be developed. Based on the results from the technical studies, stakeholder input, feedback from the Community Working Group, and public involvement, recommendations for alternative regulatory strategies will be developed (timing of this work is to be determined - TBD).

Alternative proposals will jointly developed by PSNS, EPA, Ecology, and other stakeholders. The proposals will be subjected to public review and comment. All public comments will be addressed and implementation plans will be prepared as appropriate.

4.1.3.1 Products

4.1.3.1.1 Procedure for Proposing Alternatives

4.1.3.1.2 Alternative Proposal(s)

4.2 Modeling Studies

The modeling studies have three thrusts (1) developing a capability to do modeling, (2) applying models to answer specific Ecorisk, TMDL, and other regulatory questions, and (3) using calibrated and verified models to conduct scenario simulations. An integrated modeling system is being developed that will include the hydrodynamic and contaminant transport within the receiving waters of the Inlets as well as the surrounding watershed. The modeling studies consist of a series of tasks to develop the integrated modeling capability and conduct specific model applications to support risk analysis, watershed studies, regulatory studies, and respond to stakeholder input. The final modeling product will provide the capability to simulate various risk management and policy alternatives.

Model Selection. The models selected for this portion of the project are Hydrological Simulation Program Fortran (HSPF) for the watershed and Curvilinear Hydrodynamics in 3-dimensions (CH3D) and Water Analysis Simulation Program (WASP) for the receiving waters. Although HSPF is a lumped parameter model, it is the only public-domain model currently available that can simulate both hydrological and water quality parameters at the watershed scale. The HSPF model has been widely used, it has a large user group, and it is a commonly accepted regulatory tool (<http://www.epa.gov/OST/BASINS/basinsv2.htm>).

Originally developed by the Army Corps of Engineers for the Chesapeake Bay estuarine system, CH3D calculates time-varying 3-dimensional numerical flow fields for water surface, velocity, salinity, and temperature to simulate vertical and horizontal mixing.⁹³ CH3D uses curvilinear boundary-fitted numerical grids in the horizontal plane. The gridding in the vertical direction is z-grid, which divides the water column into many layers of equal thickness, with number of layers varying from several layers for deeper regions to one layer for extremely shallow regions (< 3m). CH3D is capable of handling a variety of external forcing, including tides, winds, tributary flows, point and non-point sources, as well as baroclinic effects due to density differences between freshwater inflows and saline Inlet water.⁹⁴ Its open code, flexibility in defining model grids, and process-based numerical scheme makes CH3D very versatile in developing applications for coastal and estuarine systems. Presently, CH3D models are being

⁹³ Johnson, B. H., Kim, K. W., Heath, R. H., Butler, H. L., and Hsieh, B. B. 1991. "User's Guide for a Three-Dimensional Numerical Hydrodynamic, Salinity, and Temperature Model of Chesapeake Bay," Technical Report HL-91-20, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

⁹⁴ Wang, P.F and K.E. Richter 1999. [A Hydrodynamic Modeling Study Using CH3D for Sinclair Inlet, Draft Report.](#)

used to simulate a variety of Navy harbors including Sinclair/Dyes Inlet, Norfolk/Hampton Roads, Little Creek, and Pearl Harbor (P.F. Wang, SSC, personal communication).

The Water Analysis Simulation Program (WASP) is supported and distributed by the U.S. EPA [Center For Exposure Assessment Modeling](#) (CEAM). WASP “is a generalized framework for modeling contaminant fate and transport in surface waters. Based on the flexible compartment modeling approach, it can be applied in one, two or three dimensions and is designed to permit easy substitution of user- written routines into program structure. Problems studied using WASP framework include biochemical oxygen demand and dissolved oxygen dynamics nutrients and eutrophication, bacterial contamination, and organic chemical and heavy metal contamination.”⁹⁵

There are two components to WASP: (1) Toxics, TOXI5, which combines chemical kinetic subroutines with the WASP transport structure and simple sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the bed and overlying waters; and

(2) Dissolved Oxygen (DO)/Eutrophication, EUTRO5, which combines eutrophication kinetic subroutines with the WASP transport structure to predict DO and phytoplankton dynamics affected by nutrients and organic material.

4.2.1 Watershed Modeling

The objectives of the watershed modeling are to develop a watershed model to assess loading into the receiving waters, determine potential sources, and evaluate risk management options. When completed the watershed model will be able to simulate hydrographs (stream flow as a function of time) and pulltographs (pollution concentration as a function of time) necessary to calculate the loading of contaminants from the landscape into the Inlets. Contaminant loads from nonpoint sources, which could constitute the majority of the pollution entering into Sinclair and Dyes Inlets, need to be computed using the watershed models for the areas draining into the Inlets. These estimated loads will serve as input conditions for the receiving water models (see [Section 4.2.2](#)).

4.2.1.1 HSPF

The major creeks, which accounts for about two-thirds of the drainage area within the

Space and Naval Warfare Systems Center, San Diego, CA, November 3, 1999.

⁹⁵ US EPA CEAM 2001. U.S. EPA Center For Exposure Assessment Modeling: WASP.

<http://www.epa.gov/ceampubl/wasp.htm>

study area, are being modeled using HSPF. The HSPF models are being developed by SSC, ERDC, and CTC. SSC will be modeling Clear, Strawberry and Barker Creeks, CTC is modeling Chico Creek, and ERDC is developing the models for Gorst and Blackjack Creeks. ERDC is also overseeing and coordinating the entire watershed modeling effort. At this writing, the hydrologic properties of the study area have been defined, major subbasins within the watershed have been identified, data available on topography, soils, land use, stream flow, and water quality have been catalogued and evaluated, the initial watershed development training class has been completed, and the hydrologic components for models of Gorst, Blackjack, Chico, Clear, Strawberry, and Barker Creeks have been developed (Figure 1). Each modeling group will also participate in the watershed model intercalibration study by setting up separate models for Anderson Creek. The purpose of the intercalibration study is to compare the results of the different modeling approaches, identify any inconsistencies and deficiencies in model development, and adopt a standardized approach for watershed modeling.

4.2.1.2 Watershed model calibration and validation plan.

A watershed model calibration and validation plan has been developed that specifies the technical information, existing data sets, and monitoring data required to calibrate and validate the complete watershed model. The watershed model calibration and verification plan details how the subbasin models will be integrated into a workable whole, maintained, and utilized to conduct watershed simulations. Based on the experience gained from calibrating the HSPF models, a watershed model validation plan will be developed. The model verification plan will update the watershed calibration plan by including specifications for data required to confirm the model predictions. The plan will specify the technical information, existing data sets, and monitoring data required to verify the complete watershed model.

4.2.1.3 Smaller Subbasins and Urban Storm Water.

A scheme is needed to incorporate/aggregate the large number of small subbasins, surface flows, and storm water into the watershed model. While the HSPF models provide hydrographs and pollutographs for the larger creeks, the development and calibration of HSPF models for the all the other flows is nontrivial, let alone the large amount of field data that would be required for model calibration. As such, a modeling approach using an Artificial Neural Network (ANN) will be evaluated to predict relationships between precipitation and freshwater inflows to the Inlets. ANNs have been used extensively in signal processing and pattern identification applications.

Only recently, has ANN been used to estimate patterns in hydrology and hydrodynamics⁹⁶. The ANN model uses a feed-forward, back-propagating neural network that consists of three layers: an input layer, hidden layer, and output layer. A finite number of input nodes are used to represent precipitation prior to the time of prediction. The ANN model is then trained using the measured flow data and the corresponding precipitation data. With a back-propagation algorithm, the training optimizes the two weighting function matrices between the input and hidden layers as well as the hidden and output layers. With adequate training (learning), the ANN model is then capable of predicting flow resulting from precipitation. The modeling approach will first evaluate how well the ANN is able to predict flows in comparison to the HSPF models for Barker, Clear, and Strawberry Creeks and, if successful, develop an approach for estimating flows from the entire watershed.

To address runoff from urban areas an urban storm water model, Storm Water Management Model (SWMM)⁹⁷, will be applied. Data required for setting up the SWMM model will be identified and evaluated. The SWMM model will have to account for urban runoff from PSNS, the Naval Station, west and east Bremerton, as well as other developed areas within the study area. Partnering with the City of Bremerton, Kitsap County Surface and Storm Water Management and other stakeholders will be crucial for the successful development the SWMM model. Setting up the SWMM model will require the storm water conveyance systems to mapped and transcribed into the model code. Drawings and “as built” diagrams will need to be verified, existing data on storm water flow and contaminant levels will need to be processed, and data to fill in missing data gaps must also be obtained. Some of the data requirements may be filled using the ANN approach described above.

4.2.1.4 Oversight and Coordination for Watershed Model.

Overall coordination for watershed modeling will be provided by ERDC. ERDC shall provide oversight for the development of an overall watershed model by developing the schema for integrating subbasin submodules, evaluating submodule performance and implementation (quality assurance), and assisting in developing solutions to ensure proper application of the user controlled input (UCI) file, the watershed data management (WDM) file, and the watershed

⁹⁶ Babovic, Vladan, Rafeal Canizares, H. Rene Jensen, and Anders Klinting, 2001, “Neural Networks as Routine for Error Updating of Numerical Models”, pp181-193, Vol. 127, No. 3. , Journal of Hydraulic Engineering, American Society of Civil Engineers.

⁹⁷ OSU 2001. EPA Storm Water Management Model (SWMM), Versions 4.31 and 4.4. Department of Civil, Construction, and Environmental Engineering, Oregon State University <http://www.ccee.orst.edu/swmm/>

management system (WMS) for submodule integration. CTC shall maintain and operate a modeling data exchange web site to facilitate the development of the overall watershed model.

4.2.1.5 Apply GIS interface for displaying model calibration results and predictions

An important aspect of integrating watershed modeling with the integrated watershed-receiving water system model is to develop software that will provide a common interface between field data, model calibration results, and model predictions and simulations. One such tool is a geographic information system (GIS). A GIS “takes the numbers and words from the rows and columns in databases and spreadsheets and puts them on a map.”⁹⁸ By utilizing industry standard GIS tools, the software will provide a common interface between the real world and simulation results.⁹⁹ The GIS interface will also be used to control input and output for the receiving water model (see 4.2.2.4 below) to evaluate the watershed model performance. (TBD)

4.2.1.6 Watershed Modeling Products:

Watershed Calibration and Verification Plan
Subbasin Models for Gorst and Blackjack Creeks
Subbasin Model for Chico Creek
Subbasin Models for Clear, Barker, and Strawberry Creeks
Interlaboratory calibration on Anderson Creek
Comparison between ANN and HSPF

4.2.2 Receiving Water Modeling

The objective of the receiving water models are to assess the fate and transport of constituents in the receiving water system, to determine the potential exposure levels in the receiving water media, and to evaluate risk management options.

Status: A WASP box model has been setup to run long-term simulations (years to decades) and the kinetic subroutines from WASP have been linked directly to CH3D so that short term dynamic simulations (days to months) can be calculated. Presently, the grid for CH3D had been refined, a Lagrangian particle tracking model within CH3D has been used to calibrate the model with data from the drogue study, and a module to simulate fecal coliform growth and die

⁹⁸ ESRI 1999. What is GIS? Environmental Systems Research Incorporated, Redlands, CA.
http://www.esri.com/library/fliers/pdfs/what_is_gis.pdf

⁹⁹ Vandervoort, D. 2001. Land Use Runoff Contributions to Marine Water Bodies, Sinclair Inlet and Dyes Inlet, Kitsap County, Washington. ESRI Online Map Book Volume 16, Geography Creating Communities
http://www.esri.com/mapmuseum/mapbook_gallery/volume16/environmental4.html

off in the marine environment based on the Mancini Equation¹⁰⁰ has been added to the model code — CH3D-FC (P.F. Wang, SSC, personal communication).

4.2.2.1 CH3D

The hydrodynamic model (CH3D) been set up and calibrated for both Sinclair and Dyes Inlets (Figure 12). A commercially available software product, Surfacewater Modeling System (SMS),^{101,102} was used to efficiently create and modify the numerical grid for CH3D. This grid-generation method will save time and provide flexibility, compared to old method, for creating and refining the CH3D grids. The CH3D grid has been refined to provide higher resolution of the hydrodynamics in Dyes Inlet. A PC-based user-friendly graphics software to animate CH3D modeling results will also be developed. A beta-version of computer graphic software to animate CH3D model results is being developed to visualize model performance and develop specifications for advanced graphics display. Addenda and updates for the CH3D manual will be developed to document additions and revisions to the software code¹⁰³. Training workshops will also be held to assist in applications of the model.

4.2.2.2 WASP

The set up and calibration of the Water Analysis Simulation Program (WASP) for conducting contaminant transport modeling in Sinclair and Dyes has been completed. Both Sinclair Inlet and Dyes Inlet were divided into “boxes”, which are assigned the same characteristics and properties (Figure 13). Each box contains surface water and sediment segments. The boundaries of the boxes were designed to coalesce with sub-gridlines for CH3D so that future modifications can be made conveniently. The WASP modeling structure was designed to conduct simulations over long periods (years-decades) for use in calculating Total Maximum Daily Loadings (TMDLs) for the Inlets and provide the linkage to couple the WASP with CH3D. The WASP model will be calibrated to address the modeling questions defined in the TMDL study plan and ecorisk risk exposure assessment modeling questions:

¹⁰⁰ Mancini, J.L. 1978. Numerical Estimates of Coliform Mortality Rates Under Various Conditions. Journal WPCF (November), pp. 2477-2484.

¹⁰¹ BYU 2001. SMS Surfacewater Modeling System. Engineering Computer Graphics Laboratory, Brigham Young University. Copyright 1999 Environmental Modeling Research Laboratory.
<http://www.cwrw.utexas.edu/gis/gishydro99/byu/sms/Sms.htm>

¹⁰² EMS-I 2002. SMS Version 7.0: Surfacewater Modeling System. Environmental Modeling Systems, Incorporated, South Jordan, UT. <http://www.ems-i.com/sms.htm>

¹⁰³ Brown, J. 2001 (ed). [User's Guide For A Three-Dimensional Numerical Hydrodynamic, Salinity, And Temperature Model Of Sinclair Inlet](#). July 2001.

4.2.2.3 Model Linkage

For short-term dynamic simulations – hours, days, to months – WASP kinetic routines have been coupled directly to CH3D. This entailed two parts: 1) separation of the eutrophication kinetics from WASP and 2) merging it into CH3D. The eutrophication kinetics from the EPA's WASP was modularized and then directly linked to CH3D. The result is that important transport processes can now be modeled on short-term dynamic time scales. For longer term simulations – months, years, decades, the hydrodynamic processes from CH3D (output) will be linked to the WASP box model.

4.2.2.4 Develop GIS Interface for Model Applications

A GIS interface for routine display of model results and manipulation of model input. By expanding on the effort to develop a GIS interface for CH3D, modules will be developed to interface with the watershed model (see Section 4.2.1.5). A summary report documenting development of GIS Interface for CH3D and HSPF and GIS scripts and library routines for interface module will be prepared.

4.2.3 Model Applications

4.2.3.1 CSO Impact on Shellfish Beds

In June 2000 the Modeling Sub-Working Group of Stakeholders was established to address the issue of fecal coliform contamination of shellfish beds in Dyes Inlet from combined sewer overflows (CSOs) in the Port Washington Narrows. Participants in the working group included the Suquamish Tribe, Washington State Department of Health, City of Bremerton, Kitsap County, CTC, PSNS, and SSC. The working group determined that shellfish beds in upper Dyes Inlet remain closed in part due to uncertainty about CSO overflows in the Port Washington Narrows. A modeling study was proposed to model “typical” CSO overflow events on incoming tide. Key issues were the lack of knowledge on current and transport patterns in upper Dyes Inlet, the need for data on CSO events and discharge parameters, and other data needed to support the modeling approach. The Navy and Stakeholder Team planned and cooperatively executed a drogue and current meter study for Dyes Inlet in the fall of 2000. The CSO subworking group also identified the need to conduct a dye-release study to confirm and validate the model. In partnership with the City of Bremerton, Washington State Department of Health, Suquamish Tribe, Kitsap County SSWM, and the Bremerton-Kitsap Health District a dye-release study is being developed to address this need.

4.2.3.1.1 Drogue and Current Meter Study

During the CSO working group meetings the lack of knowledge on current and transport patterns in Upper Dyes Inlet were identified as key issues that would have to be addressed before any decision could be made to open shellfish beds in Dyes Inlet. Therefore, the participants cooperatively executed a drogue and current meter study to provided data to address key issues for the CSO modeling study. A drogue study is a very effective means of determining discharge trajectories and dispersion dynamics of simulated CSO event(s). Moreover, improvements and refinements to the model obtained from such data will result in an improved modeling capability for Sinclair Inlet as well.

The drogue and current meter study was completed in fall 2000 (Figure 14, Figure 15). Data from current meter and drogues will be used to calibrate the CH3D model for Dyes Inlet

Sampling plan and statement of purpose (Oct 2000)

Calibration of hydrodynamic portion of CH3D-FC (April 2001)

Update database with drogue study data

Display of new drogue study data (Feb 2001)

4.2.3.1.2 Model confirmation with Dye Release Study

The CSO subworking group identified the need to conduct a dye-release study to confirm and validate the model. In partnership with the City of Bremerton, Washington State Department of Health, Suquamish Tribe, Kitsap County SSWM, and the Bremerton-Kitsap Health District a dye-release study is being developed to address this need. The objectives of the dye study are to:

- (1) Simulate a CSO discharge event in the Port Washington Narrows on the incoming tide.
- (2) Provide physical and chemical data sets for validating model performance.
- (3) Develop data on ambient concentrations of fecal coliform and selected contaminants in the estuary.

Discrete samples will be collected at 8 stations within the estuary to characterize ambient conditions for fecal coliforms, conventional parameters, metals, and toxic organics. Replicate samples will be taken (at or near low tide) at each station during the shakedown cruises (T-48 h,

T-24 h), during (T0) and after the dye study (T+24). Temperature, conductivity, sechi disk depth, etc. will be measured on site, and bottle samples will be collected for laboratory analysis. Bacterial samples will be analyzed by WDOH; metals, toxic organics, and other parameters will be measured by BMSL.

Due to logistic constraints and scheduling conflicts the dye study will be conducted in March or early April of 2002. The ideal scenario would be to start injecting dye at the beginning of a flood tide at daybreak during heavy rain with little or no wind and track the plume until sundown (~12 h). Based on the preliminary model runs, it appears that a flood tide of 3-5 ft would be sufficient for model confirmation and validation. Because the model simulates the whole Sinclair-Port Washington Narrows-Dyes Inlet system, the plume movement both up the Port Washington Narrows to Dyes Inlet and down the Narrows to Sinclair Inlet will be equally valid for obtaining scientifically defensible data for model confirmation and validation (Figure 16).

The dates scheduled for the dye release are March 11/12, 2002 (primary date) and March 25/26, 2002 (backup). Note that mobilization will begin no later than 72 h before the scheduled release dates (March 8 or March 22).

[Dye Release Study in Port Washington Narrows, Draft Sampling Plan](#)

4.2.3.1.3 Simulation and Report

The fully verified and confirmed model will be used to conduct simulations of CSO releases in Dyes Inlet. A key component of this effort is to fully report and document the results of the modeling study and supporting data. This will be critical in providing the scientific and technical basis for developing policy and management decisions, documenting advances in modeling and monitoring technology, and obtaining scientific acceptance of new and emerging technology through publication in the open literature.

4.2.3.2 Modeling in Support of TMDL Development

The models will be calibrated to conduct simulations in support of TMDL Development for eutrophication/dissolved oxygen and for selected contaminants. The parameters for this task should be defined by the regulatory working group. This model application will be performed in support of the TMDL to be developed for Sinclair and Dyes Inlets.

Fecal Coliform
Metals Modeling Workplan (Copper, Zinc, Chromium, etc)

TBD

Eutrophication/dissolved oxygen
Toxic Organics Modeling Workplan
Mercury Modeling Workplan

4.2.4 Scenario Simulation

Once the models have been developed, calibrated, and used in specific modeling applications, the confirmed model can be used to evaluate “what if” scenarios. The ability to conduct scenario simulations will be crucial in evaluating potential risk management strategies, identifying pollution control options, and developing implementation plans for TMDLs. The simulations will be used to explore various waste load reduction strategies in order to determine if pollution controls proposed under a TMDL will bring the water back into compliance with state water quality standards.

Scenario Simulation Workplan (TBD)

4.3 Watershed Studies

Watershed studies are being conducted to define the environmental setting of the landscape, identify sources and volumes of runoff, evaluate the contribution of contaminants and water quality from the landscape, and identify sources of stress and impact on the ecological system.

4.3.1 Develop GIS Layers for Watershed

In order to support watershed modeling and assessment, GIS layers will be developed for the study area. A GIS layer is physical, geological, chemical, biological, or geographical data projected onto a map. The GIS layers can be used to conduct specific analyses to relate attributes of the landscape to important ecological processes. Examples of the GIS layers to be developed include:

Natural features including soils, topography, steep slopes, vegetative cover, forest, shrub, grass, and barren areas.

Man made features including land-use, urban, industrial, commercial, institutional, high density suburban, medium density suburban, low density suburban, rural residential, agricultural, and military.

Impervious surfaces estimated from landuse-based conversion factors (residential, high density, commercial etc.), roads (types) and road-density, and stormwater infrastructure.

Delineation of surface water and riparian corridors for streams, wetlands, lakes, estuaries, and near shore areas;

GIS analyses will be conducted to support watershed, ecorisk, modeling, and regulatory studies. A work plan detailing protocols for development of GIS layers analyses to be conducted, and documenting GIS-industry standards for QA/QC to be applied will be prepared. On going semi-annual reports summarizing the status and inventory of GIS layers for the watershed will be prepared. Preparation of GIS charts, maps, and presentations will be conducted in support of watershed, ecorisk, modeling, and regulatory studies (ongoing). A plan will be developed to provide access to the GIS layers and data through an internet connection.

4.3.2 Watershed Monitoring

The objectives of the watershed-monitoring program are to develop data and information to support:

- (1) Watershed modeling.
- (2) TMDL development.
- (3) Ecological assessments.

The conceptual approach for developing a cooperative watershed monitoring program is shown in Figure 17. Data are needed for water quantity (flow and precipitation), water quality, and ecological condition for streams, storm water outfalls, and point source discharges for a variety of parameters. Once the technical working groups have defined the matrix of data needed and established the sampling protocols, then the stakeholders can develop cooperative partnerships to obtain the data and information desired (i.e. “build it and they will come”). Because the scope of the project is so large it would be almost impossible for a single agency to do everything. But by combining efforts and developing mutually beneficial goals and objectives, stakeholders, working together, can succeed in achieving real progress towards the goal of improved environmental quality. When stakeholders are engaged in the technical studies and involved in developing water cleanup plans, it is much more likely that implementation will be successful. It just makes good sense to combine efforts, where possible, to achieve common goals of having clean water and a healthy environment.

The initial phase of watershed monitoring will consist of establishing stations to monitor precipitation and stream flow on selected creeks (4.3.2.1 Hydrologic and Meteorological Monitoring), collect base flow water quality data for representative streams and storm water outfalls (4.3.2.2 Water Quality Base Flow Monitoring), collect storm event samples for the major streams and stormwater outfalls (4.3.2.3 Water Quality Storm Event Monitoring), and assess the ecological condition of selected streams and sensitive habitats (4.3.2.4 Ecological Condition). Initially, base flow samples will be collected to obtain water quality data of the major streams and storm water outfalls draining into the Inlets. The sampling stations were selected to correspond to representative geographical locations, land uses, and encompass the range of impervious surfaces within the watershed (Table 5, Figure 18). The wet season base flow samples will be collected at the same time as the marine ambient and boundary condition samples are collected during the

dye-release study (see Section 4.2.3.1.2) to provide a semi-synoptic measure of water quality within the watershed (Figure 18).

4.3.2.1 Hydrologic and Meteorological Monitoring

Hydrological monitoring of key streams and rain gauges located within the watershed study area will be conducted by the KPUD. A network of stream monitoring and precipitation stations will be established which includes existing stations maintained by the KPUD, SSWM, City of Bremerton, and others as well as any additional stream gauge and precipitation stations to be established in support of PSNS Project ENVVEST. Historical stream and meteorological data collected by KPUD, SSWM, City of Bremerton, and others that is of interest to the project shall be obtained and incorporated into the database system. The data records will be made available to the technical working groups.

As agreed during the Dec. 7, 2000 technical meeting, stream gauge monitoring will be conducted according to the Kitsap Public Utilities District protocols.¹⁰⁴ The protocol includes stream gauge maintenance and calibration, data processing procedures, quality control requirements, data reporting specifications, and other actions that are necessary to assure high quality data are obtained.

New stream gauging stations were established at eight locations. A consensus among the technical team was developed for the location of the stations and for the specification of equipment and sensors to be used. New stream gauging stations were installed (Dec 2000) and monitoring was initiated (Feb 2001) for Barker Creek (BC), Clear Creek main stem (CC), Clear Creek East (CE), Clear Creek West (CW), Steele Creek (ST), Gorst Creek (GC), and Blackjack Creek (BC). A gauging station on Strawberry Creek (SC) was added in Oct 2001 (Table 5). Following the unusually high stream flows that occurred during the storm of January 8-9, 2002, the gages on Gorst and the Chico tributary on Taylor Rd were washed out. Currently, these gages are being refurbished, and will be re-established as soon as is possible (J. LeCuyer, KPUD, personal communication). There are also plans to establish another stream gaging station on Parish Creek just above where it joins with Gorst Creek. This station will allow more accurate determination of how much water is coming from pristine areas of the Gorst watershed (Gold and Green Mountain) and from developed areas along Parish Creek (Sunnyslope).

¹⁰⁴ Kitsap Public Utilities District (KPUD) 2000. Precipitation, water level, & stream flow data for Kitsap County: Volume I: February 2000, Data through October 1999. Kitsap Water Resources Monitoring Program.

Data from existing rain gages established by KPUD and rain gages established by Kitsap County SSWM in the Chico Creek watershed will also be monitored by KPUD. In addition, data from rain gages maintained by the City of Bremerton, National Weather Service, KING5 SchoolNet, the US Navy, and others will be obtained to support the project. If necessary, new precipitation stations will be established. The technical working group will develop a consensus for the location of the stations and specification of equipment and sensors to be used. Currently, the City of Bremerton is planning to install additional rain gages in the Gorst and Anderson Creek watersheds (Chance Berthiaume, City of Bremerton, personal communication).

A minimum of three years of stream and rain data is recommended as optimal to support the HSPF model calibration. If feasible, preliminary data will be made available for project use only. Additionally, data from other stream and precipitation monitoring locations monitored by the KPUD, SSWM, City of Bremerton, etc will be obtained and made available to the technical to the technical working groups. All final data deliverables, technical reports, and associated metadata will be made available to other interested stakeholders and the public.

4.3.2.2 Water Quality Base Flow Monitoring

The objective of sampling the streams and runoff during the dry and wet seasons is to obtain an estimate of contaminant loading into the receiving waters during periods of low rain fall (dry period) and high rain fall when soils are (wet period). Discrete grab samples will be collected at each stream location during the dry and wet weather sampling periods. The base flow sampling will be initiated in March 2002 (wet period) at selected stations in the watershed (Figure 18, Table 5). The stations groups include:

Group 1: Stream stations located near the mouths of the major streams that are being modeled using HSPF.

Group 2: Stream stations located at important tributaries and other smaller streams.

Group 3: Stations are representative of the major storm water discharges from the City of Bremerton (Group 3a) and Kitsap County (Group 3b).

Marine: Stations are representative of boundary and ambient conditions in the Inlets.

Group 4: Stations are representative of storm water runoff from PSNS and the Naval Station.

The station locations, corresponding watersheds, and the cumulative surface area and impervious surfaces represented by the stream and storm water sampling locations accounts for approximately 70% of the surface area and 65% of the impervious surfaces within the study area (Table 6). Preliminary estimates of loading based on land use for selected watersheds (B. Skahill, ERCD, Personal Communication, Table 6b) suggests that these stations will be representative of the types of loading expected from the watershed. The data from the stream monitoring will be used to evaluate the accuracy and uncertainty of estimating runoff as a function of land use (see 4.3.3).

Samples from the base flow and marine monitoring will be analyzed for a suite of conventional parameters, total and dissolved metal, and organics (Table 7). Ultra clean sampling techniques and trace level analytical chemistry will be used to obtain low detection level results. Samples will be collected in accordance with accepted sampling^{105,106} and analytical chemistry¹⁰⁷ QA/QC protocols.

Execution of this study will involve partnering with the KPUD, City of Bremerton, and Kitsap SSWM for sample collection and Bremerton Kitsap Health District for monthly monitoring fecal coliform and dissolved oxygen in streams and outfalls.

Draft Base Flow Sampling Plan (In Prep)

4.3.2.3 Water Quality Storm Event Monitoring

The objective of sampling the streams during storm events is to obtain an estimate of contaminant loading into the receiving waters during periods of high flow. Optimally a minimum of three discrete storm events will be captured at each stream location (Group 1 and 2 Stream Stations, Table 6).

(1) Characterize runoff from the surrounding watershed, and

(2) Calibrate and verify HSPF watershed models being developed for selected streams and

¹⁰⁵ Ward, W. (ed) 2001. Stream Sampling Protocols for the Environmental Monitoring and Trends Section. October 2001, Washington State Department of Ecology. Publication No. 01-03-036. <http://www.ecy.wa.gov/biblio/0103036.html>

¹⁰⁶ Caltrans 2000. Guidance: Stormwater Monitoring Protocols (Revised). California Department of Transportation, CTSW-RT-00-005, Sacramento, CA. <http://www.dot.ca.gov/hq/env/stormwater/special/>

¹⁰⁷ Johnston, R.K. and R. Valenti, 2001. Specifying and evaluating analytical chemistry requirements for ecological risk assessments. Marine Environmental Support Office Technical Memorandum 99-01, Space and Naval Warfare Systems Center, San Diego, CA, 35pp. <http://meso.nosc.mil/newsltr/Refs/MESO-01-TM-01.pdf>

drainage areas within the watershed.

Discrete storm events will be targeted for obtaining flow proportional composite samples for chemical analysis. Target sampling events will be defined in the Sampling and Analysis Plan for each stream to be sampled. The sampling events will be targeted to capture storm events that result in more than 0.25 inches of rain within a 24 hour period preceded by a discernable period of no or low rain fall.

Flow proportional composite samples will be collected from discrete storm events. The composite sample will be collected to capture at least 75% or the first 24 hours of a storm event, whichever comes first. Flow-proportional composite samples are a composite of multiple sample aliquots, each of which represents a predetermined flow volume. The sample aliquots are collected at flow volume intervals and combined in a manner that creates a larger volume sample representative of the entire monitored flow period. The principal advantages of flow-proportional composites (over time-proportional composites or grab samples) are that flow-proportional composites are not biased by over- or under-sampling any part of the hydrograph, and they allow direct estimation of Event Mean Concentration (EMC) and Event Mass Load (EML), without making assumptions about the shape of the hydrograph or the relationship between pollutant concentrations and flow rates.¹⁰²

The parameters to be analyzed include physical, biological, total metal, dissolved metal, ionizable organics, aromatic hydrocarbons, chlorinated benzenes, phthalate esters, and other organic compounds including total PCB's (Table 7). The analytical parameters are based on sediment management standards, contaminants included on the 303(d) list for the study area, and screening for pesticide and herbicide compounds.

Execution of this study will involve partnering with the City of Bremerton and Kitsap County SSWM for monitoring storm water outfalls from the City and County, respectively. Additionally, Bremerton Kitsap Health District will conduct monthly monitoring of fecal coliform and dissolved oxygen in streams and outfalls.

Storm Event Sampling Plan (In Prep)

4.3.2.4 Ecological Condition

An ecological effects monitoring and QA/QC plan will be developed to provide the details

of the ecological effects monitoring to be conducted for Phases I, II and III of the watershed monitoring. The plan will detail the frequency of sampling, the sampling parameters, and the sampling methodology to be used. Based on the results of the initial phases, subsequent phases will be modified and fine-tuned to better achieve project goals. A baseline benthic survey was report completed in July 2001.

Benthic Macroinvertebrate Sampling Field Activity and Data Summary Report (Draft July 31, 2001)

4.3.3 Landscape Ecology

4.3.3.1 Relative flows for Subwatersheds

In support of a Total Maximum Daily Load (TMDL) study in Sinclair Inlet and Dyes Inlet, estimates of mean annual surface runoff were required from the various ungaged systems draining into the two inlets, not only to support the development of a Water Quality Analysis Simulation Program (WASP) model for the two inlets, but also a watershed monitoring plan.

Data relevant to runoff generation and surface flow; such as, elevation, soils, land use and land cover, and vegetative cover, are readily available today at multiple scales in raster or grid cell Geographic Information Systems (GIS) format, and GIS technology provides a means for data storage, handling, mapping, and evaluation. Three GIS-based approaches that have been developed by separate groups involved in the TMDL study to estimate mean annual surface runoff for the large number of ungauged basins that drain into Sinclair Inlet and Dyes Inlet will be evaluated. These methods range from the simple to the sublime. They include

1. a simple loss function approach based on a raster data product of percent impervious cover,
2. the curve number approach developed by the Soil Conservation Service (SCS) of the U.S. Department of Agriculture, and
3. a distributed application of the ‘surface runoff function’ originally derived by Eagleson (1978)¹⁰⁸.

All three methods are based on the deterministic eight-neighbor (D-8) method. Pour points may be symbolized to show mean annual surface runoff and the relative contribution of each land use class within a given watershed. Runoff volume may subsequently be multiplied by mean runoff concentrations for constituents of interest to obtain the estimated load of each constituent

¹⁰⁸ Eagleson, Peter S. 1978. “Climate, Soil, and Vegetation 5. A Derived Distribution of Storm Surface Runoff.” *Water Resources Research*, 14(5), 741-748.

from each watershed.

4.3.3.2 Estimate Water Quality as a Function of Land Use

Estimates of water quality, as a function of land use will be developed. This is the GIS analysis using default values for loadings¹⁰⁹ (US EPA 1983) to develop an estimate of which areas of the watershed will have the highest potential for contaminant loading.

4.3.3.3 Coordination with Chico Watershed Planning Project

Kitsap County, in cooperation with state and federal agencies, the University of Washington, Washington State University, and local landowners, is conducting the Chico Watershed Project in the Chico Watershed to establish how the county works with local residents to plan future development in local watersheds¹¹⁰. By working with local residents, the project is designing future development scenarios for the watershed and developing quantifiable parameters and variables (metrics) that can be used to evaluate the changes of future landscapes on the watershed's natural resources like drinking water and wildlife¹¹¹. Members of the PSNS Project ENVVEST technical team are participating in the technical aspects the Chico Watershed Planning Project by providing expertise in modeling, water quality assessment, and landscape analysis. Specifically, the technical team is developing metrics that relate land use to water quality (see 4.3.3.2 above) to model the effect on water quality from changes in land use. If the metrics prove useful for the Chico Watershed Planning Project they could be scaled up and applied to larger watersheds and basins. Community Working Group members can also participate in the Chico Watershed Planning Project by contacting Paul Nelson at (360) 337-4653 or email [natural resources](#). Anyone interested in knowing more or becoming a Chico Creek Watershed Advisory Committee Member should contact [Jan Koske](#) at (360) 337-4650

4.4 Ecological Studies and Risk Assessment

This section defines the risk assessment tasks and ecological studies required completing the risk assessment. Risk assessment tasks are defined to formulate the problem, conduct a screening level risk assessment, and prepare a baseline risk assessment for the receiving waters

¹⁰⁹ US EPA 1983. Results of the Nationwide Urban Runoff Program EPA841-S-83-109 12/83.

<http://www.epa.gov/owow/info/PubList/publist4.html>

¹¹⁰ Kitsap County 2002. [Chico Watershed Planning Project](http://www.kitsapgov.com/nr/chico.htm). <http://www.kitsapgov.com/nr/chico.htm>

¹¹¹ Hulse, D, J. Eilers, K. Freemark, C. Hummon, and D. White, 2000. Planning alternative future landscapes in Oregon: Evaluating Effects on Water Quality and Biodiversity. *Landscape Ecology* 19:pp1-19.

and streams within the watershed. Ecological studies will be performed to develop the data and information necessary to perform the risk assessment.

4.4.1 Ecological Risk Assessment

NOTE: Ecorisk tasks on hold pending completion of TMDL Study Plan and Watershed Monitoring Plan.

4.4.1.1 Problem Formulation

The objectives of problem formulation are to develop the conceptual model that will be used to guide the risk assessment process, identify the assessment endpoints, the exposure pathways, and the stressors of concern. The problem formulation for the watershed needs to include both the receiving water system (Inlets) as well as the streams. The problem formulation should incorporate stakeholder inputs and be understandable to nontechnical reviewers and the general public.

Draft Strawman Prepared Jan 2000

Poster on Problem Formulation Presented during Public Workshop June 2000

Conceptual Approach Presented at 21 JUL 2000 Meeting with Ecology

Draft Problem Formulation Report for Inlets (TBD)

Problem Formulation for Streams

The Ecorisk Problem Formulation will be extended to define the assessment endpoints, receptors of concern, exposure pathways, and contaminants of concern for streams within the watershed. The current ecological status and condition of major streams within the watershed will be reviewed and the problem formulation will be incorporated into the Watershed Problem Formulation Report.

4.4.1.2 Screening Level Risk Assessment

A screening level risk assessment work plan will be developed. The purpose of the screening level risk assessment is to evaluate which components of the ecosystems that are at risk, identify potential risk drivers, and identify gaps in data and knowledge that are needed to complete the baseline risk assessment. Once the database with historical data on the inlet is

available, the screening level risk assessment will proceed. A technical work plan will be developed to identify the assumptions, benchmarks, and analysis activities to be used to complete the screening level risk assessment for the Inlets and Streams. The screening level risk assessments for the Inlets and Streams will be integrated into a single report.

Draft Screening Level Risk Assessment (TBD)

Final Screening Level Risk Assessment (TBD)

4.4.1.3 Develop Ecorisk Data Gap Monitoring Plan

Based on the results of the screening level risk assessment (4.4.1.2 above), critical data needed to complete the risk assessment will be identified. A data gap monitoring and assessment plan will be developed to fill the Ecorisk data gaps. If deemed appropriate, the QwikLite Bioassay, which uses dinoflagellate bioluminescence to assess potential toxicity of surface water, sediment pore waters, and effluents^{112,113} and a biomarker assay (Comet Assay) to detect genotoxic and cytotoxic effects of pollutants in vertebrates and invertebrates.¹¹⁴

Draft Ecorisk Data Gap Monitoring Plan (TBD)

Final Ecorisk Data Gap Monitoring Plan (TBD)

4.4.1.4 Baseline Risk Assessment

Based on the results of the screening level risk assessment and the Ecorisk Data Gap Monitoring the work and QA/QC plans will be developed for performing a watershed scale baseline risk assessment. The baseline risk assessment will update the problem formulation and conceptual model, conduct the exposure and effects assessment, characterize risk, identify risk drivers, and derive conclusions about risk and the confidence associated with the conclusions. The baseline risk assessment will also provide recommendations for long term monitoring and risk verification studies.

¹¹² Lapota, D., C.H. Liu, D.E. Rosenberger and J.I. Banu 1998. [Use of a Rapid Bioluminescent Test \(QwikLite\) Using Dinoflagellates to Assess Potential Toxicity of Sediment Pore Waters](#). SSC San Diego SD 087 Revision 1, May, 1998.

¹¹³ NRaD Environmental Sciences Division 1995d. [QwikLite Bioassay System: A Unique Test for Determining Toxicity Using Bioluminescent Dinoflagellates](#)

¹¹⁴ NRaD Environmental Sciences Division 1995b. [Biochemical Assessment of Environmental Contamination: Biomarker](#). NRaD TD 2781, March 1995

Draft Baseline Risk Assessment (TBD)

4.4.1.5 Long Term Monitoring and Risk Verification

Upon completion of the risk assessment a long term monitoring plan will be developed that will identify data needed to track long term trends in the watershed, address key areas of uncertainty in the risk assessment hypotheses, and provide the basis for verifying conclusions about risk and evaluating the efficacy of risk management options.

Draft Long Term Monitoring and Risk Verification Plan (TBD)

4.4.2 Develop Understanding of Ecological System**4.4.2.1 Water Quality Surveys**

Water quality surveys utilizing the Marine Environmental Survey Capability of R/V *ECOS*^{115, 116, 117} were conducted in Sinclair and Dyes Inlets during 1997 and 1998 (Fig. 19). They provided baseline data on circulation, hydrography, and water quality for dry and wet weather conditions.¹¹⁸ This effort produced critical data for assessing the status of water quality in the Inlet. Continued monitoring is required to provide data to support development of TMDLs, model applications (see 4.2.3 above), and address long-term trends, particularly for quantifying the impact from managing pollution within the watershed. The measurements could also be used to validate/update and eventually feed the watershed-hydrodynamic-transport models developed for the Inlets (see 4.2.2.3 above).

Water quality surveys similar to those performed in 1997/98 will be conducted with emphasis on sampling in the vicinity of sources. Further monitoring efforts should include measurements in receiving waters made in concert with watershed monitoring (see 4.3.2 above), and monitoring of point and nonpoint source discharges at the shipyard during periods of intense industrial operations suspected to release elevated contaminants in effluents (from historical NPDES and storm water monitoring). The most likely time period to experience increased releases would be the wet winter season. Additional surveys during the dry season will also be

¹¹⁵ NRaD Environmental Sciences Division 1995c. [Marine Environmental Survey Capability](#). NRaD TD 2789, March 1995

¹¹⁶ SSC Environmental Sciences Division 1998c. [Marine Environmental Quality Assessment and Management](#). SSC San Diego SD 133, November 1998.

¹¹⁷ Tayon, James (Ed.) 1994. [The Navy Studies a River](#). NRaD TD 2679, September 1994

¹¹⁸ Katz et al. 1999. [Sinclair Inlet Water Quality Assessment](#). Puget Sound Wastewater Technology and Evaluation Research Project, Space and Naval Warfare Systems Center, San Diego, Ca. September 30, 1999.

conducted to provide data on base flow conditions with minimal stormwater influence to address the long-term assimilative capacity of the inlet.

Sinclair Inlet Water Quality Assessment (Sept. 1999)

4.4.2.2 Benthic Flux Assessment

Site characterization studies, NPDES monitoring, and recent regulatory listings all point to sediments as a potentially important repository for contamination in Sinclair Inlet. It is also recognized that the subsequent remobilization of these contaminants represents a potential source to the Inlet that may be important in the overall budget and development of TMDLs. The remobilization may also be an important indicator of exposure in areas where the initial discharge material is substantially particle-bound, as may be the case for dry-dock discharges and stormwater flows.

To address contaminant flux issues, the Navy-developed Benthic Flux Sampling Devices (Figure 20)¹¹⁹ were deployed in April/May 2000 to make direct measurements of the flux of contaminants from the sediment and measure sediment oxygen demand at nine sites within Sinclair and Dyes Inlets. The instrument allows the *in-situ* quantification of contaminant mobility from sediments. Measurement sites in the inlet were chosen to represent a range of bulk contaminant loadings and geochemical conditions. Analytes were selected based on previous monitoring and site characterization data. The resulting flux measurements will be used on an inlet-wide basis to provide mass loading terms for the TMDL study. On a local basis, the results will be used to examine the mobility of contaminants from sediments, which may be impacted by specific point source discharges. The flux measurements will be coordinated with proposed monitoring, risk assessment, and modeling studies.

Sampling Plan April 2000

Draft Report Feb 2001 (Davidson et al. 2001)

Final Technical Report (Mar 2002)

Seasonal variation in sediment flux rates, changes in conditions in the Inlets from

¹¹⁹ Hampton, T. W. and D. B. Chadwick, 2000. Quantifying In Situ Metal Contaminant Mobility in Marine Sediments. Space and Naval Warfare Systems Center TECHNICAL REPORT 1826, June 2000, San Diego, CA. <http://www.spawar.navy.mil/sti/publications/pubs/tr/1826/tr1826.pdf>

dredging and cleanup activities, and improved management practices indicate that sediment flux rates are not static and may vary with time. The purpose of this task is to provide period benthic flux measurements in selected areas of Inlet to support risk assessment and modeling activities.

Seasonal Benthic Flux Monitoring (TBD)

4.4.2.3 Contaminant Mass Balance for Sediment

In order for the Sinclair Inlet stakeholders to manage the sediment quality, a sediment contaminant mass balance is needed. This study will determine the inventory of contaminants in the sediments of the Inlets, assess the present sources of contaminants, and estimate the rate of natural recovery for contaminated sediment. The study will involve collecting sediment cores and suspended sediment (Figure 21). These samples will be analyzed for contaminants of concern, including metals, polynucleararomatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), butyltins, and other parameters that identify contaminant sources (sewage, highway runoff, and marinas). The atmospheric deposition will be estimated from sediment cores from reference lakes in the watershed. A model for sediment quality will be developed for prediction of future sediment quality for various contaminant loading scenarios.

Sampling and QA/QC Plan for Development of a Contaminant Mass Balance for Sediment (Jan. 2002)

4.4.2.4 Evaluation of Fluvial Deposits

Fluvial deposits associated with stream and storm water drainage need to be assessed to develop a record of inputs, determine if there are any unidentified stressors, and evaluate potential sources. Rapid assessment techniques¹²⁰ that have been developed by SSC will be utilized to provide detailed information on chemical contamination in fluvial deposits around the margins of the Inlets. Rapid assessment techniques include sediment characterization by an X-ray fluorescence (XRF) technique used to rapidly measure metals in sediment (EDXRF) and an immunoassay procedure to determine PCBs and PAHs. Approximately ten percent of the samples will be selected for analytical chemical analysis to provide a comparison between the rapid assessment methods and full analytical chemistry analysis. If deemed appropriate, the QwikLite Bioassay which uses dinoflagellate bioluminescence to assess potential toxicity of surface water, sediment pore waters, and effluents, and a biomarker assay (Comet Assay) to detect genotoxic

¹²⁰ (Kirtay et al. 2000, Lapota et al. 1998, NRaD 1995b)

and cytotoxic effects of pollutants in vertebrates and invertebrates will be used to assess the ecological significance of chemical contamination levels (Figure 22).

4.4.3 Ecological Systems Analysis

The objective of this task is to develop a means of relating stressor levels to ecological impacts at the population and community level. This is especially important for evaluating long term viability for ecological resources such as fish and shellfish and their response to fishing pressure, habitat loss, and chemical stressors. Another critical aspect is the bioaccumulation of contaminants (tracers) through the food chain. The goal of the ecological systems analysis is to develop a framework to relate management options to ecological response so that the ecological consequences of management actions can be evaluated and predicted. One possible approach to achieve this goal is to develop an Ecopath with Ecosim (version 4.0, Fisheries Centre 2001) model for the study area.

Developed jointly by the International Center for Living Aquatic Resources Management (ICLARM) and the Fisheries Centre of the University of British Columbia, Ecopath with Ecosim is a Windows software-based approach for modeling mass-balance and feeding interactions or nutrient flow within ecosystems (Figure 23, Figure 24). “The software is designed to help construct a (simple or complex) model of the trophic flows in an ecosystem, to analyze the system, and to study interactions in the system. Its successful application represents a move toward sustainable management of ecosystems.”¹²¹

Currently an Ecopath with Ecosim model is being developed for the South Puget Sound¹²². Sponsored in part by the Northwest Indian Fisheries Commission and the Puget Sound Action Team, the model evaluates changes in species abundance in the South Puget Sound from the 1970s to the 1990s. The modeling study has provided a focus to collate and bring together ecological data from government, university, tribal, and other open/gray literature sources to develop a much better understanding of the South Puget Sound Ecosystem (Andy Rankis, Northwest Indian Fisheries Commission, personal communication). For example, the Ecopath study for South Puget Sound showed that there is a critical lack of knowledge about the lower

¹²¹ Fisheries Centre 2001. [Ecopath with Ecosim: No fish is an island](http://www.ecopath.org). University of British Columbia, Fisheries Centre, Vancouver, British Columbia, Canada. <http://www.ecopath.org>

¹²² Preikshot, Dave and Alasdair Beattie, 2001. [A Dynamic Ecosystem Model of South Puget Sound](#), Session 5A. University of British Columbia Fisheries Centre, presentation at the [2001 Puget Sound Research Conference](#), February 12 to 14, 2001, Bellevue, Washington.

levels of the food change in the Puget Sound ecosystem (Scott Redman, Puget Sound Action Team, personal communication). There is ongoing interest in developing a “skeleton” Ecopath with Ecosim model for the Georgia Straits/Puget Sound ecological system that could be adapted for applications for specific areas (such as Sinclair and Dyes Inlets) and management questions (ie shellfish harvesting in Dyes Inlet). The modeling process requires the cooperation of many groups to develop the data and information necessary to calibrate and validate the model. The modeling process can act as a catalyst to focus separate efforts into a common goal (such the need to conduct an ecological risk assessment and the need to inventory and manage ecological resources). The Fisheries Centre is also working on a module that can simulate the movement of chemicals through the food chain (Ecotrace, Villy Christensen, UBC Fisheries Centre, personal communication). Initial collaboration with the Fisheries Centre indicates that Ecotrace, if fully developed, could be a very promising tool for evaluating not only contaminant accumulation in the food chain, but ecosystem level effects of contaminant accumulation and exposure (Ecorisk) as well.

4.4.3.1 Develop Approach for Systems Level Analysis

The objective of this task is to evaluate and demonstrate the applicability of the modeling approach (“proof of concept”) and develop a technical approach for the application of Ecopath with Ecosim model for the study area.

Proof of concept for development of Ecopath with Ecosim (TBD)

Proof of concept for development of Ecotrace (TBD)

4.4.3.2 Implement Systems Level Analysis

Implement ecosystem level analysis (TBD)

4.5 Core Capabilities

Core capabilities are tools and resources that are needed to complete the tasks outlined in the technical objectives. Core capabilities will be used to support the technical team during execution of specific tasks, assist the ENVVEST Co-Partners and stakeholders in developing compliance options and regulatory strategies, and facilitate the exchange of data and information to project participants, the community working group, and the general public. Core capabilities include database management support, GIS support, and web-based project management.

A critical need of the project is sharing data and information from a wide variety of data sources, models, technical studies, and other environmental management details with project participants and stakeholders. As discussed during the meeting of 20 FEB 2002, US EPA Region X has offered to help address this need by providing the Rapid Access Information System (RAINS), currently being developed by Region X's Data Mapping and Analysis Program, to support the PSNS Project ENVVEST. If successfully implemented, RAINS would offer a web-enabled system to provide users with maximum spatial and thematic navigational flexibility in rapidly accessing pan-media content, applications, models, analytical tools, and related links.

The development of RAINS for PSNS Project ENVVEST would be a welcome contribution to the project. If fully implemented, it is understood that "RAINS" would appear on the title page and on all subsequent web pages; that any publicly accessible version of the website would be available and configured for linking to and from other instances of RAINS; that all non-proprietary, unclassified, and approved for public release data and information on the website would be available to other instances of RAINS; and that any enhancements, newly developed applications, tools, techniques, or functionalities developed as part of PSNS Project ENVVEST will be fully documented and readily available to other instances of RAINS.

It is also understood that EPA Region X will assist in the initial setup and configuration of RAINS for PSNS Project ENVVEST, that guidance on how to adapt RAINS to PSNS Project ENVVEST will be provided, and critical technical enhancements and improvements needed to meet the requirements of PSNS Project ENVVEST will be identified. Future collaborative efforts to enhance RAINS functionality will be developed on a case-by-case basis.

The development of an instance of RAINS for PSNS Project ENVVEST would mutually

benefit the project participants and stakeholders and assure better dissemination of technical data and information developed for the project. An instance of RAINS that is currently available on the world wide web can be accessed at <http://bluesky.pnl.gov>.

4.5.1 Database Management Support

This task provides database management support for the PSNS ENVVEST Project. Database management support involves routine maintenance and operation of the database system, including but not limited to user control and access, software licensing and updates, data storage and backup, and providing periodic status and database dumps of data pertinent to the PSNS ENVVEST Project. The database management system will provide assistance to project participants by loading specified data sets, providing access, assisting in developing routine and specialized queries to the database, establishing and maintaining reliable and robust network communication protocols, and archiving metadata and data source information.

Database management plan for routine maintenance and operation of the database system (June 2001)

Data reporting specification for use by project participants in preparing data deliverables for inclusion into the database system. (June 2001)

4.5.1.1 Developing specifications for a generalized user interface for the database system.

Based on usage of the database, specifications for a generalized user interface will be developed. (TBD)

4.5.2 Geographical Information System Support

A range of GIS support capabilities will be required for the PSNS ENVVEST Project. This task will involve routine maintenance of GIS, including but not limited to user control and access, software licensing and updates, data storage and backup, and providing periodic status and database dumps of GIS data pertinent to the PSNS ENVVEST Project. The the GIS will support project participants by conducting specific GIS analyses, preparing GIS overlays, charts, and maps, and documenting such analyses according to GIS industry standards. Based types of GIS analyses required, specifications for application of an internet map server to conduct web-based GIS analysis will be developed.

GIS management plan for routine maintenance and operation of the GIS and database system (June 2001)

Data reporting specification for use by project participants in preparing data deliverables for inclusion into the GIS system (June 2001).

Standard operating procedures SOPs to be followed by project participants and outside requestors for requesting routine and specialized GIS analyses. (June 2001)

Specifications for application of an Internet map server to conducted web-based GIS analysis and prepare a pilot demonstration of such. (Sep 2001)

4.5.3 Web-Enabled Project Documentation

Successful and efficient execution of this project will require the development of a PSNS ENVVEST Project website. This task will involve hosting a project intranet web site on the world wide web that is password controlled and accessible only to project participants. The project intranet site will host project information including, but not limited to, technical working group meeting minutes, draft and final work plans and reports, schedules, data exchanges sites, data, documentation, and other information, needed to support day to day execution of the PSNS ENVVEST project. Upon review and approval by PSNS and the ENVVEST Copartners, final deliverables will be prepared for posting on the public Internet.

Website management plan for routine maintenance and operation of the PSNS ENVVEST Project website. The management plan will detail security requirements, approvals for granting access, backup procedures, website functionality, and other technical considerations. (TBD)

Developing standard operating procedures to be followed by project participants for review and approval by PSNS and the ENVVEST Copartners prior to posting to the public world wide web. (TBD)

PSNS Project ENVVEST Website online (TBD)

5. Tables

Table 1. Beneficial uses for water bodies in Washington State.

Beneficial uses for water bodies in Washington State.

domestic water supply	resident fish & aquatic life
industrial water supply	wildlife & hunting
irrigation	fishing
livestock watering	boating
anadromous fish passage	water contact recreation
salmonid fish passage	aesthetic quality
salmonid fish rearing	hydropower
salmonid fish spawning	commercial navigation & transportation

Table 2. History of chronological events and major studies for Sinclair and Dyes Inlets. Data obtained from [The Sun 2001b](#), [PSNS 2001](#), [Horn 1999](#), and [U.S. Census Bureau 2001](#)).

Kitsap	Population Bremerton PSNS	NAVY	Cities
		1890 1891 Puget Sound Naval Station Established 1896 Drydock 1 Completed	
1,200		1900 1891 Puget Sound Navy Yard Established 1904 Naval Magazine Puget Sound Established	1901 City of Bremerton Founded 1903 Bremerton - 16 saloons for 1200 people 1903 Port Orchard Incorporated Logging and farming in Kitsap
4,055		1910 1914-1918 WW I Increased capacity for new vessel construction and overhauls; Submarine construction; Naval Ammunition Depot	
	4,000 6,500	1915 1919 Begin Expansion of PSNY	
12,256		1920 1926 Pier 6 constructed	
	2,500	1925 1930s Upland Construction	
10,000	4,000 3,100	1930 1938-1945 WWII - Major expansion of PSNY. New shore facilities, drydocks 4 & 5; 394 built or repaired	
	6,000	1935 1945 Puget Sound Naval Shipyard established 1947 Mothball fleet in Sinclair Inlet	1947 Bremerton Begins Wastewater Treatment
80,000	32,000	1940 1950-1953 Korean War - modernization and new production	
	10,000	1945 mid-1950s Construction of guided missile frigates	
		1950 1959 Ammunition Depot Closed 1961 Navy Nuclear Power Program at PSNS	
		1955 1964 Polaris Submarines; Jackson Park Housing 1967 Naval Supply Center	
		1960 1970s Repair and overhaul 1973 Base closures at Boston & Hunters Point	1972 Water Pollution Control Act
		1965	
		1970	

			1975	1975 Carrier overhaul; Bangor Trident Base Established	1977 Clean Water Standards
			1980	1980 Notice of Hazardous Waste Activity	
			1985	1983 Initial Assessment Study (Beginning of Remedial Investigations)	1985 Upgrade Bremerton Wastewater Treatment Plant
					1987 CSOs prohibited; 1988 Sinclair/Dyes Inlet Action Plan
			1990		1990 Urban Bay Action Prog. & Ambient Monitoring
			1991		1991 Puget Sound Sediment Survey
			1992	1992 WDOE Enforcement Order Issued	1992 Contaminants in Fish Tissue
			1993	1993 Base Closures at Mare Island and Philly	1992 Bremerton CSO reduction plan
			1994	1994 Bremerton Naval Complex listed on NPL	1994 Construction for CSO reduction begins
			1995	1995 Base Closures at Long Beach and Charleston	
			1996		
			1997	1997 ROD for Operable Unit A (upland)	
			1998		
			1999		1999 Bremerton private separation ordinance
231,969	37,259	8,000	2000	2000 ROD for Operable Unit B (marine sediments)	2000 Stormwater separation;
			2001	2001 Pit CAD Cleanup	2000 Central Sound Ambient Monitoring Report

Table 3. The parameters, media, and water bodies included on the 1998 303(d) list within the study area for streams (a), marine waters (b), and tissue (c). The grid cell number refers to location of the impaired waterbody, the parameter is the constituent that exceeded quality criteria, the medium identifies whether the quality criteria were exceeded in water, sediment, or biota (tissue concentration).

Table 3a. Water bodies and stream segments on 303(d) list for water.

Grid Cell Number	Parameter	Medium	Was grid cell or segment on the 1996 list?	Water Body Identifier	Water Body Name
47122F6E4	Fecal Coliform	Water	No	WA-15-0040	SINCLAIR INLET
47122G7A0	Fecal Coliform	Water	Yes	WA-15-0050	DYES INLET
47122G6A9	Fecal Coliform	Water	Yes	WA-15-0050	DYES INLET
	Fecal Coliform	Water	Yes	WA-15-0051	CLEAR CREEK
	Fecal Coliform	Water	Yes	WA-15-5100	BARKER CREEK
	Fecal Coliform	Water	Yes	WA-15-4000	GORST CREEK
	Fecal Coliform	Water	Yes	WA-15-4200	BLACKJACK CREEK
	Fecal Coliform	Water	Yes	WA-15-4400	ANNAPOLIS CREEK
	Fecal Coliform	Water	Yes		BEAVER CREEK
	Fecal Coliform	Water	Yes		BEAVER CREEK
	Fecal Coliform	Water	Yes	WA-15-9150	KITSAP LAKE
	Total Phosphorus	Water	Yes	WA-15-9150	KITSAP LAKE

Table 3b. Grid cells and parameter on 303(d) list for sediment from Sinclair and Dyes Inlets.

Grid Cell Number	Parameter	Medium	Was grid cell or segment on the 1996 list?	Water Body Identifier	Water Body Name
47122F6F3	1,4-Dichlorobenzene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	2,4-Dimethylphenol	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Arsenic	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Benz(a)anthracene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Butylbenzyl phthalate	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Cadmium	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Chrysene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Copper	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Indeno(1,2,3-cd)pyrene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Lead	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Mercury	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Zinc	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Benzo(ghi)perylene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Benzoic acid	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Bis(2-ethylhexyl) phthalate	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Butylbenzyl phthalate	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Cadmium	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Chrysene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Copper	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Fluoranthene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Indeno(1,2,3-cd)pyrene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Lead	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Mercury	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Phenanthrene	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6F4	Zinc	Sediment	Yes	WA-15-0040	SINCLAIR INLET
47122F6I8	Bis(2-ethylhexyl) phthalate	Sediment	Yes	WA-15-0050	DYES INLET
47122F6I8	Cadmium	Sediment	Yes	WA-15-0050	DYES INLET
47122F6I8	Mercury	Sediment	Yes	WA-15-0050	DYES INLET
47122F6I8	Phenol	Sediment	Yes	WA-15-0050	DYES INLET
47122F6I8	Sediment Bioassay	Sediment	No	WA-15-0050	DYES INLET
47122F6I8	Silver	Sediment	Yes	WA-15-0050	DYES INLET

Table 3b. Grid cells and parameter on 303(d) list for tissue from the study area.

Grid Cell Number	Parameter	Medium	Was grid cell or segment on the 1996 list?	Water Body Identifier	Water Body Name
47122F6D4	Arsenic	Tissue	No	WA-15-0040	SINCLAIR INLET
47122F6E2	Arsenic	Tissue	No	WA-15-0040	SINCLAIR INLET
47122F6F1	Dieldrin	Tissue	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	Aldrin	Tissue	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	PCB-1254	Tissue	Yes	WA-15-0040	SINCLAIR INLET
47122F6F3	PCB-1260	Tissue	Yes	WA-15-0040	SINCLAIR INLET
47122F6I8	Antimony	Tissue	Yes	WA-15-0050	DYES INLET
47122F6I8	Arsenic	Tissue	Yes	WA-15-0050	DYES INLET
47122F6I4	Arsenic	Tissue	No	WA-15-0050	DYES INLET
47122F6H2	Arsenic	Tissue	No	WA-15-0050	DYES INLET
47122F6I6	Arsenic	Tissue	No	WA-15-0050	DYES INLET
47122F6G7	Arsenic	Tissue	No	WA-15-0050	DYES INLET
47122G7A0	Arsenic	Tissue	No	WA-15-0050	DYES INLET
47122G6E8	Arsenic	Tissue	No	WA-15-0050	DYES INLET
47122F6I8	Benz(a)anthracene	Tissue	Yes	WA-15-0050	DYES INLET
47122F6I8	Benzo(b)fluoranthene	Tissue	Yes	WA-15-0050	DYES INLET
47122F6H2	Benzo(b)fluoranthene	Tissue	No	WA-15-0050	DYES INLET
47122F6G7	Benzo(b)fluoranthene	Tissue	No	WA-15-0050	DYES INLET
47122F6I8	Bis(2-ethylhexyl) phthalate	Tissue	Yes	WA-15-0050	DYES INLET
47122F6I8	3,3'-Dichlorobenzidine	Tissue	Yes	WA-15-0050	DYES INLET
47122F6I8	Chrysene	Tissue	Yes	WA-15-0050	DYES INLET
47122F6I8	Pentachlorophenol	Tissue	Yes	WA-15-0050	DYES INLET
47122F6I8	Mercury	Tissue	Yes	WA-15-0050	DYES INLET
47122F6G0	Arsenic	Tissue	No	WA-15-0030	PORT ORCHARD PASSAGE

Table 4. List of studies on the study area available through Ecology's web site.

year	pub_no	title	Author
1974	74-e63	Survey at the City of Bremerton's Charleston Plant. Memo to John Glynn	Lee, P.
1975	75-e09	Kingston STP. Memo to John Glynn.	Cregg, H.
1975	75-e10	Silverdale STP. Memo to John Glynn.	Cregg, H.
1978	78-e33	Bremerton (Manette) Class II and Receiving Water Survey. Memo to Dave Wright.	Yake, W. and J. Bernhardt
1979	79-e07	Charleston STP Class II Inspection. Memo to Craig Baker.	Cloud, G.
1979	79-e22	Kitsap County Sewer District #5 Class II Inspection and Receiving Water Study. Memo to David Wright February 23, 1979.	Morhous, M. and D. Anderson
1980	80-e01	Port Orchard Sewage Treatment Plant Class II Inspection. Memo to Dave Wright.	Abercrombie, W. and W. Yake
1980	80-e06	Review of Proposals for Discharge of Treated STP Effluent into Sinclair Inlet. Memo to Dick Cunningham.	Determan, T.
1981	81-e12	The Effects of Two Sewage Treatment Plant Discharges on Sinclair Inlet Receiving Waters. Memo to Dave Wright.	Determan, T.
1988	88-e33	Bremerton Wastewater Treatment Plant Class II Inspection.	Reif, D.
1990	90-e72	Aluminum Company of America (ALCOA) Class II Inspection, January 1990	Zinner, L.
1990	90-e73	Port Orchard Wastewater Treatment Plant Class II Inspection, January 1989	Zinner, L.
1992	92-23	Marine Water Column Ambient Monitoring Plan: Final Report	Janzen, C.
1992	92-47	Puget Sound Ambient Monitoring Program, Marine Sediment Monitoring Program: Annual Report 1990	Striplin, P., P. Sparks-McConkey, D. Davis, and F. Svendsen
1992	92-47	Puget Sound Ambient Monitoring Program, Marine Sediment Monitoring Program: Annual Report 1990	Striplin, P., P. Sparks-McConkey, D. Davis, and F. Svendsen
1992	92-e08	Bremerton Storm Drain Sampling Progress Report	Cubbage, J.
1992	92-e09	Contaminants in Fish and Clams in Sinclair and Dyes Inlets	Cubbage, J.
1992	93-87	Puget Sound Ambient Monitoring Program 1992: Marine Sediment Monitoring Task Annual Report 1992	Dutch, M., H. Dietrich, and P. Striplin
1993	93-41	Marine Water Column Ambient Monitoring Program: Wateryear 1992 Data Report, Final Report.	Janzen, C.D. and L.B. Eisner
1993	93-e01	Relative Dispersion of Water Masses Near Department of Ecology Long-Term Monitoring Stations in Puget Sound Model	Albertson, S.
1994	94-210	Marine Water Column Ambient Monitoring Program 1993	Newton, J.A., S.A. Bell, M.A. Golliet
1994	94-93	Puget Sound Ambient Monitoring Program Marine Sediment Monitoring Task Annual Report 1991	EILS

1994	94-e02	Marine Water Column Ambient Monitoring Program: Wateryear 1994 Long-Term Monitoring Implementation Plan	Bell, S.A. and J.A. Newton
1994	94-e28	Marine Sediment Monitoring Program Progress Report	Llanos, R.
1995	95-306	City of Port Orchard Sewage Treatment Plant Class II Inspection	Hoyle-Dodson, G.
1995	95-324	Marine Water Column Ambient Monitoring Program: Wateryear 1995 Long-Term Monitoring Implementation Plan	Newton, J.A.
1995	95-342	Drainage Basin Tracing Study: Phase II Chemicals Found in Storm Drains & Outfalls to Sinclair & Dyes Inlet	Cubbage, J.
1995	95-345	1992 Sinclair and Dyes Inlet Seasonal Monitoring Report	Albertson, S., J. Newton, L. Eisner, C. Janzen, and S. Bell
1995	95-352	Metals Concentrations in Rivers and Streams Dropped from the 1994 Section 303(d) List	Hopkins, B.
1996	96-335	Watershed Briefing Paper for the Kitsap Basin Watershed	Johnson, A.
1997	97-316	Washington State Marine Water Quality in 1994 and 1995	Newton, J.A.
1998	98-300	Washington State Pesticide Monitoring Program: 1995 Surface Water Sampling Report	Davis, D.
1998	98-312	Washington State Pesticide Monitoring Program: 1995 Fish Tissue Sampling Report	Davis, D.
1998	98-323	Marine Sediment Monitoring Program I - Chemistry & Toxicity Testing. 1989 - 1995	Llanos, R.
1998	98-328	Marine Sediment Monitoring Program II - Distribution & Structure of Benthic Communities in Puget Sound - 1989-1993	Llanos, R.
1998	98-338	Washington State Marine Water Quality in 1996 and 1997	Newton, J.A.
1998	98-e01	Data Report on Jackson Park/Erlands Point Clam and Sediment Samples. Memo to Craig Thompson, TCP. (March 6 memo + March 23 correction memo)	Johnson, A.
1999	99-352	City of Bremerton Wastewater Treatment Plant, Class II Inspection, June 21-23, 1999	Golding, S.
2000	00-03-019	PCB Levels in Bottom Sediments from Lower Sinclair Inlet	Norton, D.
2000	00-03-055	Sediment Quality in Puget Sound: Year 2 - Central Puget Sound	Dutch, M., S. Aasen, K. Welch, NOAA et al.

Table 5. Stream (a), storm water (b), and marine (c) station locations for dry and wet base flow (Grab Samples) and flow proportional (Storm Event Samples) sampling.

a. Stream Stations	Code	Group	Grab Samples*	Storm Event Samples	Water Quality Station		GAGE LOCATION		Comment
					dd mm. Longitude	dd mm. Longitude	ddmmss Latitude	ddmmss Longitude	
Group 1 Stations		6							
BARKER CREEK	BA	1	6	3	47 38.368	122 40.038	473836	1223928	Barker Crk @ Barker Crk Road (co-located with flowgage)
BLACKJACK CREEK	BL	1	6	3	47 30.117	122 38.633	473007	1223838	Blackjack Crk (upper main stem) @ SR-16 crossing (co-located with flow gage)
CLEAR CREEK	CC	1	6	3	47 39.908	122 40.958	473847	1224138	Clear Crk (mai nstem) @ Silverdale Way & Waaga Way (co-located with flow gage)
CHICO CREEK (Main Stem)	CH	1	6	3	47 35.58	122 42.544	473536	1224227	Chico Crk (main stem) @ golf course (co-located with flow gage)
GORST CREEK	GWQ	1	6	3			473139	1224200	Gorst Crk (upstream of Jarsted Park and upstream of Parish Crk off Bremerton city Watershed Road #2000) (gages will be downstream on Gorst main stem and on Parish)
STRAWBERRY CREEK	SC	1	6	3	47 38.783	122 41.633	473847	1224138	Strawberry Crk @ former Silverdale Water Bldg (co-located with flow gage)
Group 2 Stations		6							
ANDERSON CREEK - BREM.	AC	2	2	3	47 31.983	122 40.867	473159	1224052	Anderson Crk @ Bremerton Water Well Site (co-located with flow gage)
CHICO TRIB AT TAYLOR RD	CT	2	2	3	47 35.164	122 42.983	473511	1224255	Chico Crk (Wildcat & Lost tribs combined) @ Taylor Rd (co-located with to be installed flow gage)
CLEAR CREEK EAST	CE	2	2	3	47 40.057	122 40.949	474003	1224125	Clear Crk (east fork) @ Schold Rd (access from skateboard park) (gage is just upstream across Schold Rd)
CLEAR CREEK WEST	CW	2	2	3	47 39.917	122 41.06	474011	1224125	Clear Crk (west fork) @ Schold Rd (access from skateboard park) (gage is upstream at Clear Creek Rd)
DICKERSON CREEK	DI	2		3	47 35.156	122 42.897	473510	1224249	Chico Crk (Dickerson Crk trib) @ Taylor Rd (co-located with flow gage)
KITSAP CREEK (Below Kitsap Lake)	KC	2	2	3	47 34.762	122 42.7	473447	1224239	Chico Crk (kitsap Crk) @ Kitsap Lake outlet (co-located with flow gage)
OLNEY CREEK (KARCHER CREEK)	OC	2	2	3	47 32.738	122 36.768	473239	1223642	Olney Crk @ Annapolis STP (flow gage is just upstream on private property)

b. Storm Water Stations	Code	Group	Grab Samples*	Storm Event Samples							
Group 3 Stations		6									
City of Bremerton Storm Water Callow Ave	SW1	3a	6	3	47 33.236	122 39.450	47 33 16	122 39 12	Outfall comes out near Missouri Gate in Cove next to Carrier Mouthball fleet		
City of Bremerton Storm Water Pacific Ave	SW2	3a	6	3			47 33 37	122 37 44	Outfall comes out under PSNS Pier 7		
City of Bremerton Storm Water Pine Rd	SW3	3a	6	3	47 35.179	122 38.766	47 35 08	122 38 37	Lions Park Boat Ramp		
City of Bremerton Storm Water Trenton Ave	SW4	3a		3	47 34.121	122 36.488	47 34 08	122 36 28	Bottom of Trenton Rd. near Gazebo on Heron Point		
City of Bremerton Storm Water Stephenson Creek	SW5	3a	6	3	47 34.928	122 38.199	47 34 53	122 38 11	Lendt Park on beach		
Kitsap County Storm Water Silverdale (Bay S/SandP)	SW6	3b	6	3	47 39.027	122 41.564			Bucklin Hill Rd & Bay Shore drainage ditch next to Sandpipers		
Kitsap County Storm Water Gorst (Navy City Metals)	SW7	3b	6	3	47 31.753	122 41.93			Gorst near Wigwam Tavern		
c. Marine Boundry/Ambient Conditions**	Code	Group	Grab Samples**		dd.	dd.					
Port Orchard Passage	M1	4	3		47.63285	122.58476					
Rich Passage	M2	4	3		47.5784	122.53643					
Sinclair Outer	M3	4	3		47.56258	122.60348					
Sinclair Inner	M4	4	3		47.54215	122.66491					
Rocky Point	M5	4	3		47.61044	122.68106					
Erlands Point	M6	4	3		47.59924	122.68106					
Windy Point	M7	4	3		47.57256	122.67512					
Oyster Bay	M8	4	3		47.62447	122.69194					
Group 4 Stations		8									
d. PSNS Storm Water											
PSNS storm water	PSNS										
(Data obtained from CTC's Storm Water Monitoring Program)											

* Half of the samples taken during winter (wet) and half during summer (dry) base flow periods.

**Samples will be taken during the CSO Dye Release study

Table 6. The station locations, corresponding watersheds, and the cumulative surface area and impervious surfaces represented by the stream and storm water sampling locations (A). The preliminary estimate of loading based on land use for selected watersheds (B, B. Skahill, ERCD, Personal Communication).

A.						
Station Code	Watershed ID	Name	Area m²	%Cumulative Area	Impervious Surface m²	%Cumulative Impervious Surface
SW1, SW2, PSNS	16	West Bremerton	14452244	5.73%	12618000	14.37%
CC, CE, CW	195268	Clear Creek	22024281	14.46%	10799100	26.67%
BL	660593	Blackjack Creek	34260719	28.04%	8159400	35.96%
CH, CT, KC	390989	Chico Creek	42124499	44.73%	5380200	42.09%
BA	244328	Barker Creek	10183611	48.77%	3528900	46.11%
SC	207583	Strawberry Creek	7684633	51.81%	3528000	50.13%
OC	643582	Wilson Creek	4988926	53.79%	3518100	54.13%
SW3	475246	Pine Rd	3433388	55.15%	3131100	57.70%
GWQC	726883	Gorst Creeek	24312800	64.79%	2586600	60.64%
SW4	502306	Trenton Ave	1821026	65.51%	1274400	62.10%
SW7	15	Navy City Metals	2545764	66.52%	840600	63.05%
SW6	195907	Bay Shore-Bucklin	987778	66.91%	757800	63.92%
AC	728787	Anderson Creek	5237769	68.98%	468900	64.45%
SW8	1	Manchester	1780162	69.69%	375300	64.88%
SW5	485966	Stephenson Cr.	409403	69.85%	325800	65.25%

Table 6. Continued.

B. Estimated Loading (B. Skahill, ERDC, Personal Communication)						
Watershed Name	Nitrogen kg/yr	Phosphorous kg/yr	Fecal Coliforms 10¹⁶ CFU/yr	Lead kg/yr	Copper kg/yr	Suspended Sediment 10⁵ kg/yr
Clear Creek	15639	2261	11.02	102.0	126.0	4.35
Blackjack Creek	27296	2691	8.56	66.0	887.0	3.09
Chico Creek	23472	1962	5.88	36.5	52.0	1.66
Barker Creek	10368	1035	4.00	32.2	42.0	1.46
Strawberry Creek	6763	777	3.60	26.1	35.0	1.14
Pine Rd	7782	108	4.05	34.7	44.0	1.49
Gorst Creeek	18650	1133	3.13	25.1	32.5	1.12
Anderson Creek	6539					

Table 7. Parameters for base flow and marine ambient monitoring.

Conventionals/Physicals	Streams	Storm Water	Marine
Alkalinity, Total (as CaCO ₃)	X	X	
Hardness (as CaCO ₃)	X	X	
Biological Oxygen Demand (BOD) (5 days, 20oC)	X	X	
Chemical Oxygen Demand (COD)	X	X	
Total Solids, Total Suspended Solids	X	X	
Total Petroleum Hydrocarbon (TPH) - diesel/oil	X	X	
Secchi Disk Depth			X
Total Organic Carbon (TOC)	X	X	X
Laser Induced Suspended Solids LISST (Grain Size)	X	X	X
Nutrients			
Ammonia Nitrogen	X		
(Nitrate + Nitrite) Nitrogen	X	X	X
Total Nitrogen (TKN)	X	X	X
Total Phosphorus	X	X	X
Orthophosphate Phosphorus	X	X	X
Total Metal			
ALUMINUM	X	X	X
ARSENIC	X	X	X
CADMIUM	X	X	X
CHROMIUM	X	X	X
COPPER	X	X	X
LEAD	X	X	X
MERCURY	X	X	X
SILVER	X	X	X
ZINC	X	X	X
Dissolved Metal (0.45 um filter)			
CADMIUM	X	X	X
COPPER	X	X	X
LEAD	X	X	X
SILVER	X	X	X
ZINC	X	X	X
Organics			
NAPHTHALENE	X	X	X
ACENAPHTHYLENE	X	X	X
ACENAPHTHENE	X	X	X
FLUORENE	X	X	X
PHENANTHRENE	X	X	X
ANTHRACENE	X	X	X
2-METHYLNAPHTHALENE	X	X	X
FLUORANTHENE	X	X	X
PYRENE	X	X	X
BENZ(A)ANTHRACENE	X	X	X
CHRYSENE	X	X	X
TOTAL BENZOFLUORANTHENES	X	X	X
BENZO(A)PYRENE	X	X	X
INDENO (1,2,3,-C,D) PYRENE	X	X	X
DIBENZO (A,H) ANTHRACENE	X	X	X
BENZO(G,H,I)PERYLENE	X	X	X
DI-N-BUTYL PHTHALATE	X	X	X
BUTYLBENZYL PHTHALATE	X	X	X
BIS (2-ETHYLHEXYL) PHTHALATE	X	X	X
PCB Congener (NOAA NS&T 20 congeners)	X	X	X

Table 8. Analytical parameters for storm event sampling.

Conventional/Physicals	Aromatic Hydrocarbons
Alkalinity, Total (as CaCO ₃)	NAPHTHALENE
Hardness (as CaCO ₃)	ACENAPHTHYLENE
Biological Oxygen Demand (BOD) (5 days, 20oC)	ACENAPHTHENE
Chemical Oxygen Demand (COD)	FLUORENE
Total Solids	PHENANTHRENE
Total Suspended Solids	ANTHRACENE
Total Petroleum Hydrocarbon (TPH) - diesel	2-METHYLNAPHTHALENE
Total Petroleum Hydrocarbon (TPH) - oil	FLUORANTHENE
Total Organic Carbon (TOC)	PYRENE
Grain Size	BENZ(A)ANTHRACENE
	CHRYSENE
	TOTAL BENZOFLUORANTHENES
	BENZO(A)PYRENE
	INDENO (1,2,3,-C,D) PYRENE
	DIBENZO (A,H) ANTHRACENE
	BENZO(G,H,I)PERYLENE
Nutrients	Pesticides and Herbicides
Ammonia Nitrogen	Aldrin
(Nitrate + Nitrite) Nitrogen	a-BHC
Total Nitrogen (TKN)	b-BHC
Total Phosphorus	d-BHC
Orthophosphate Phosphorus	g-BHC
Probe	CHLORDANE
pH	4,4'-DDT
Turbidity	4,4'-DDE
Dissolved oxygen	4,4'-DDD
Temperature	DIELDRIN
Salinity (Conductivity)	a-ENDOSULFAN
	B-ENDOSULFAN
	ENDOSULFAN SULFATE
	ENDRIN
	ENDRIN ALDEHYDE
	HEPTACHLOR
	HEPTACHLOR EPOXIDE
Total Metal	Chlorinated Benzenes
ANTIMONY	1,2-DICHLOROBENZENE
ARSENIC	1,4-DICHLOROBENZENE
CADMIUM	1,2,4-TRICHLOROBENZENE
CHROMIUM	HEXACHLOROBENZENE
COPPER	Phthalate Esters
IRON	DIMETHYL PHTHALATE
LEAD	DIETHYL PHTHALATE
MANGANSES	DI-N-BUTYL PHTHALATE
MERCURY	BUTYL BENZYL PHTHALATE
NICKEL	BIS (2-ETHYLHEXYL) PHTHALATE
SILVER	DI-N-OCTYL PHTHALATE
TIN	
ZINC	
Dissolved Metal (0.45 um filter)	Other Organics
CADMIUM	DIBENZOFURAN
COPPER	HEXACHLOROBUTADIENE
LEAD	N-NITROSODIPHENYLAMINE
NICKEL	TOTAL PCB'S
SILVER	
ZINC	
Ionizable Organic Compounds	
PHENOL	
2-METHYLPHENOL	
4-METHYLPHENOL	
2,4-DIMETHYL PHENOL	
PENTACHLOROPHENOL	
BENZYL ALCOHOL	
BENZOIC ACID	

6. Figures

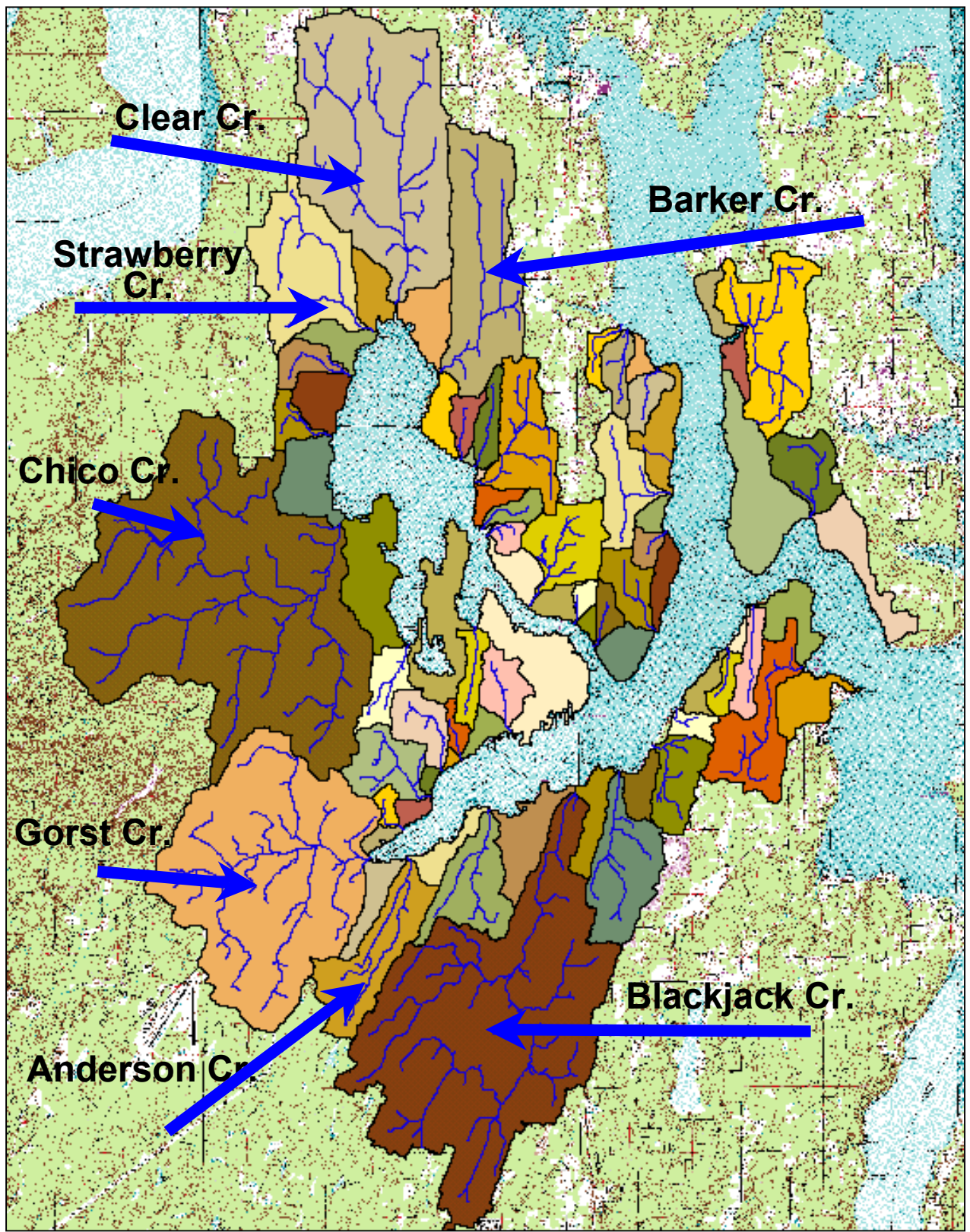


Figure 1. The study area consisting of the marine waters of Sinclair and Dyes Inlets and the surrounding watershed and the major subbasins for which watershed models are being developed.

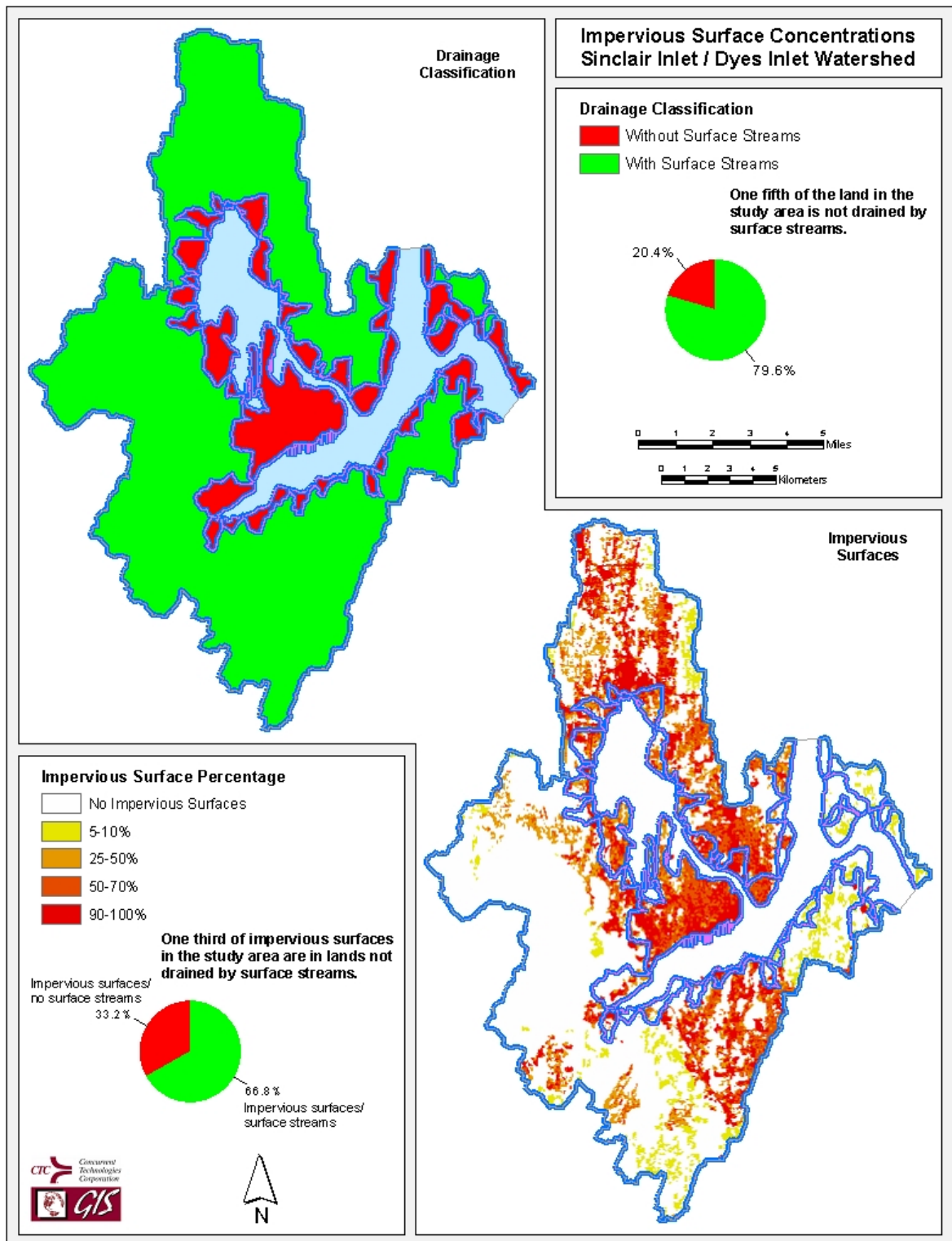


Figure 2. The amount of the study area that is drained by stream networks (upper figure) and the location of impervious surfaces within the study area (lower figure) (from Vandervoort 2001).

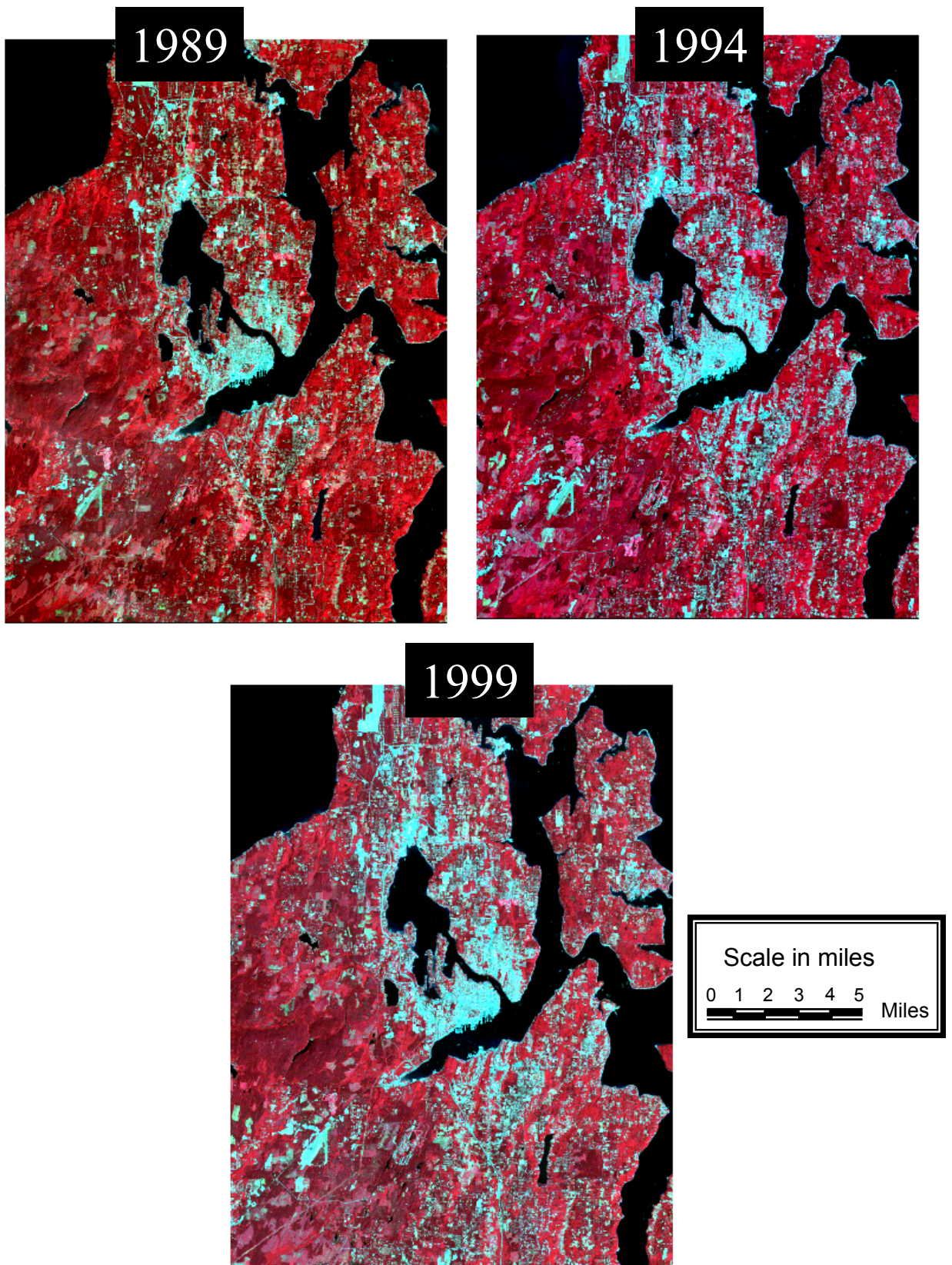


Figure 3. Land use changes suggested by multispectral analysis of satellite imagery of the study area from 1989 to 1999 (from Vandervoort 2001). Light blue areas indicate more impervious surfaces and reddish areas indicate more vegetation.

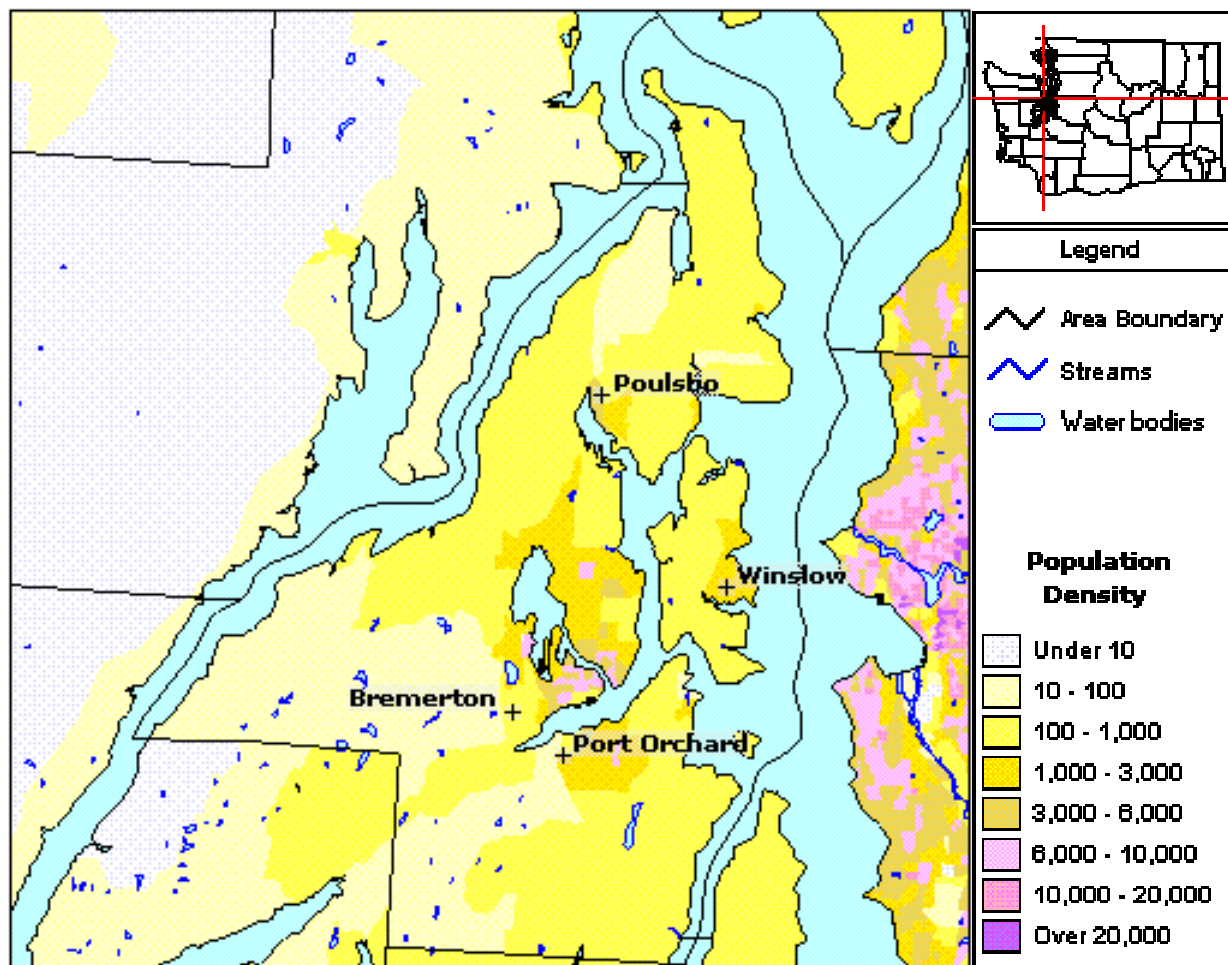


Figure 4. Population density for Kitsap County from 2000 Census data (RAINS 2002)
<http://bluesky.pnl.gov>.

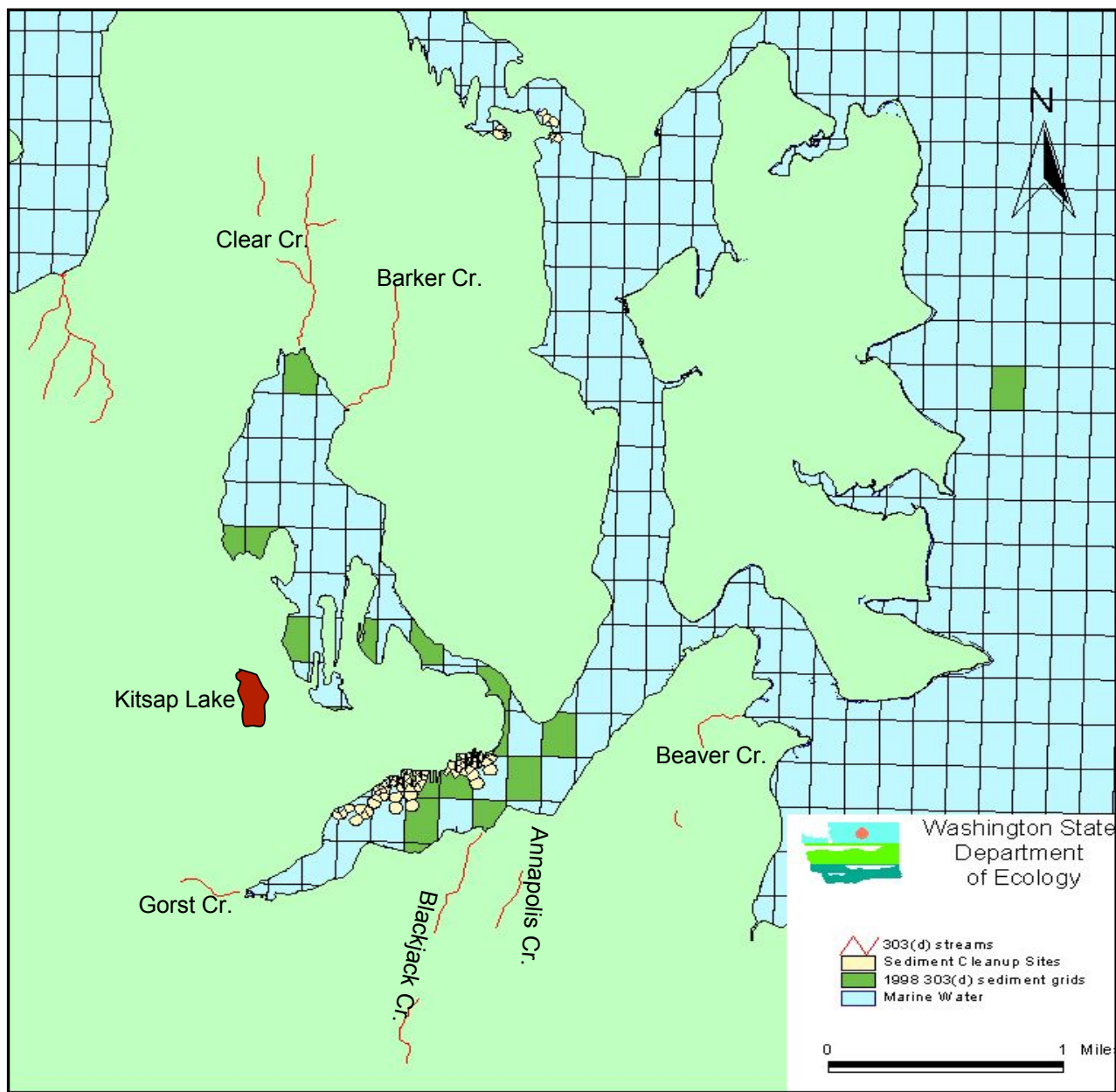


Figure 5. Stream segments, sediment cleanup sites, and sediment grids listed on the 1998 303(d) list.

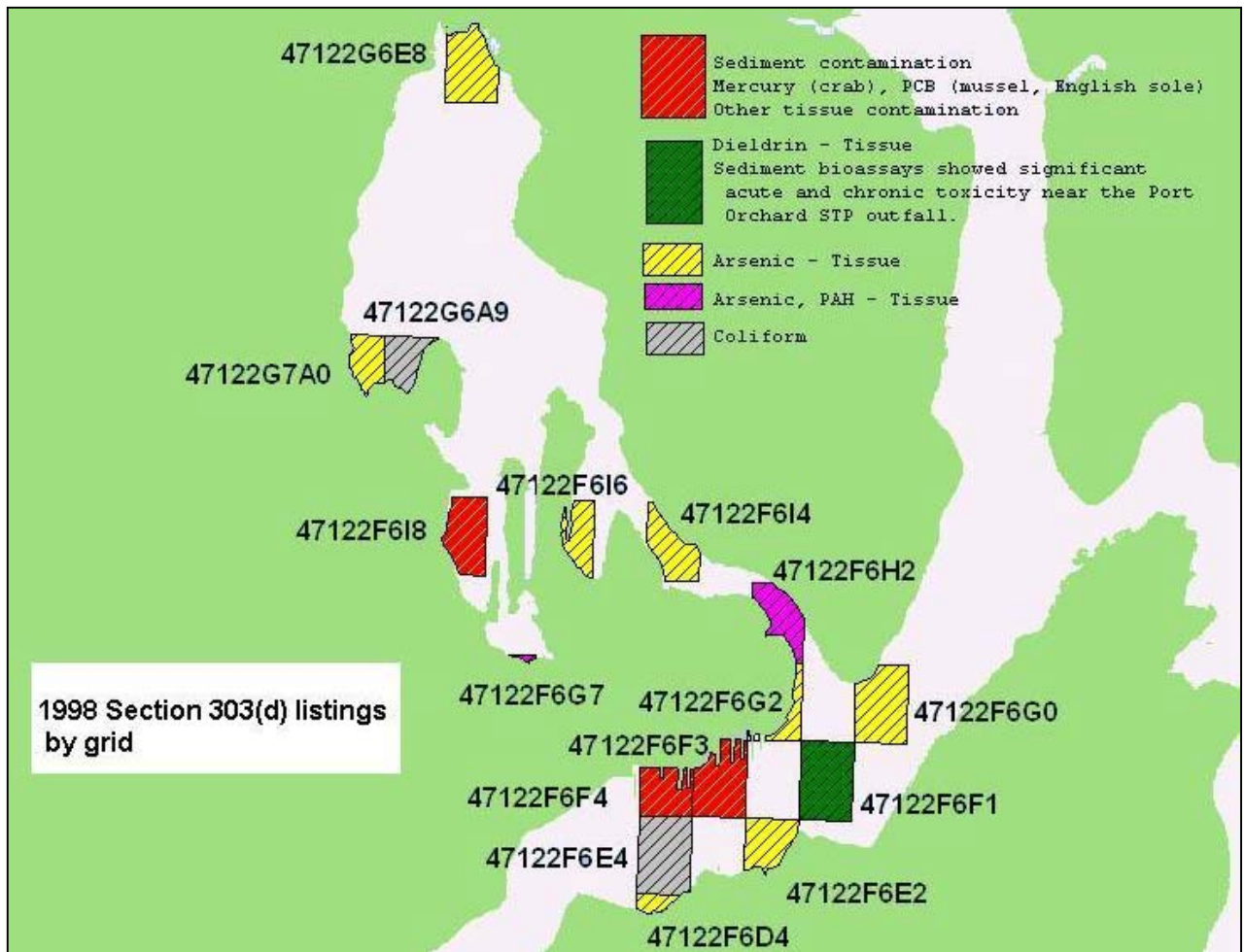


Figure 6. Sediment grids and contaminants on the 1998 Section 303(d) list for Sinclair and Dyes Inlets.

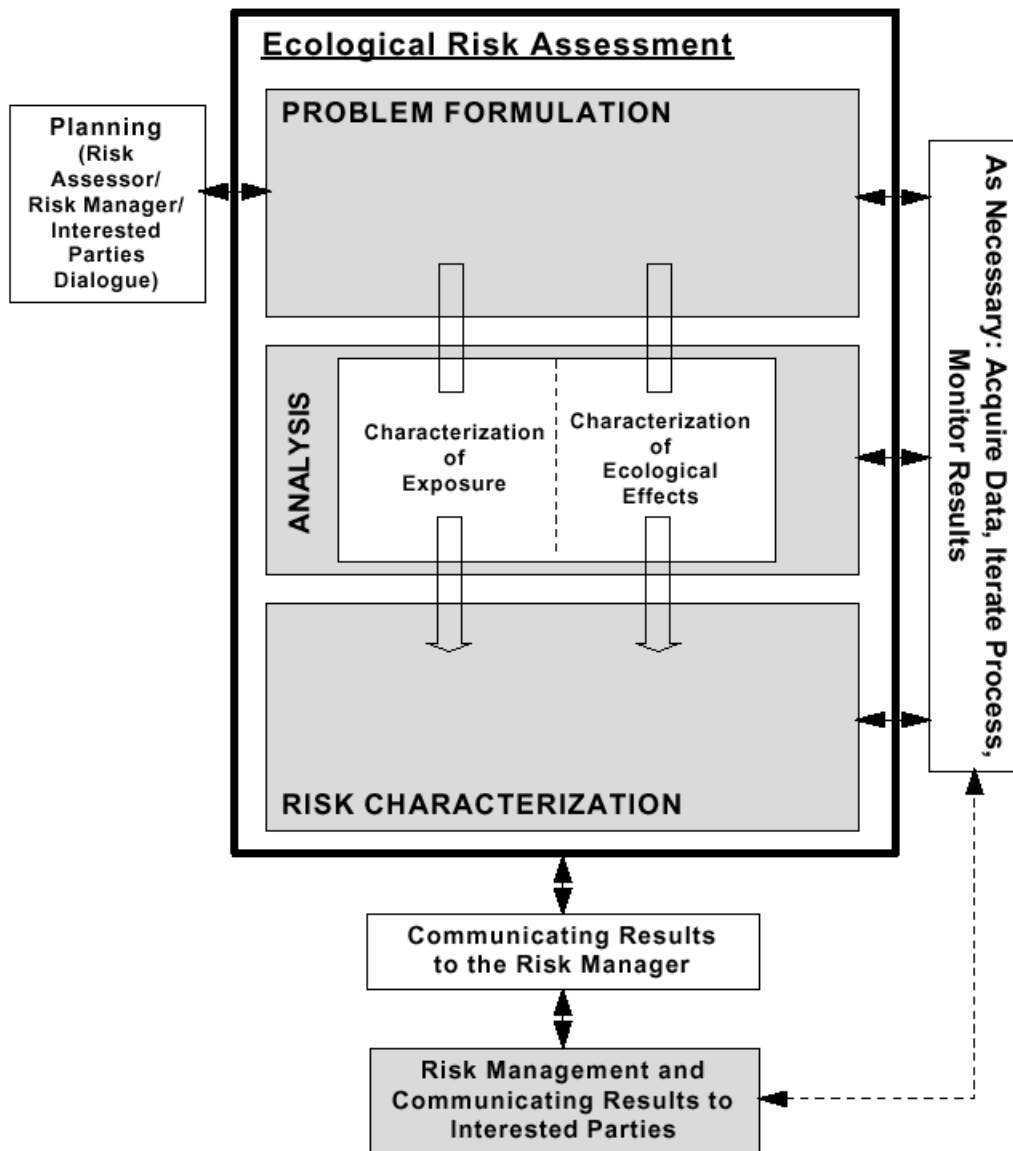


Figure 7. Framework for Ecological Risk Assessment (US EPA 2000).

Inputs Into the Ecological Risk Assessment Process

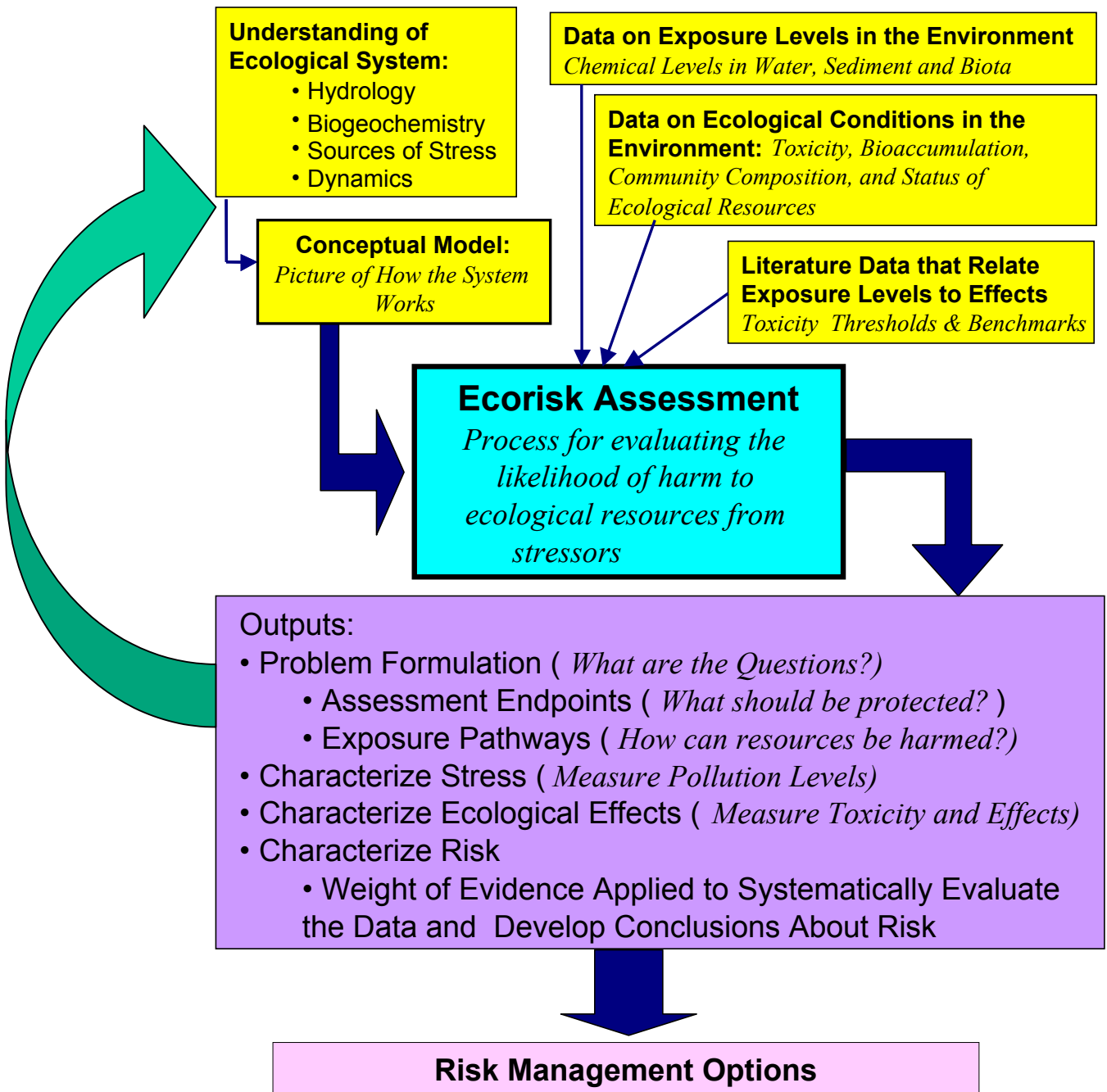


Figure 8. The Ecological Risk Assessment Process.

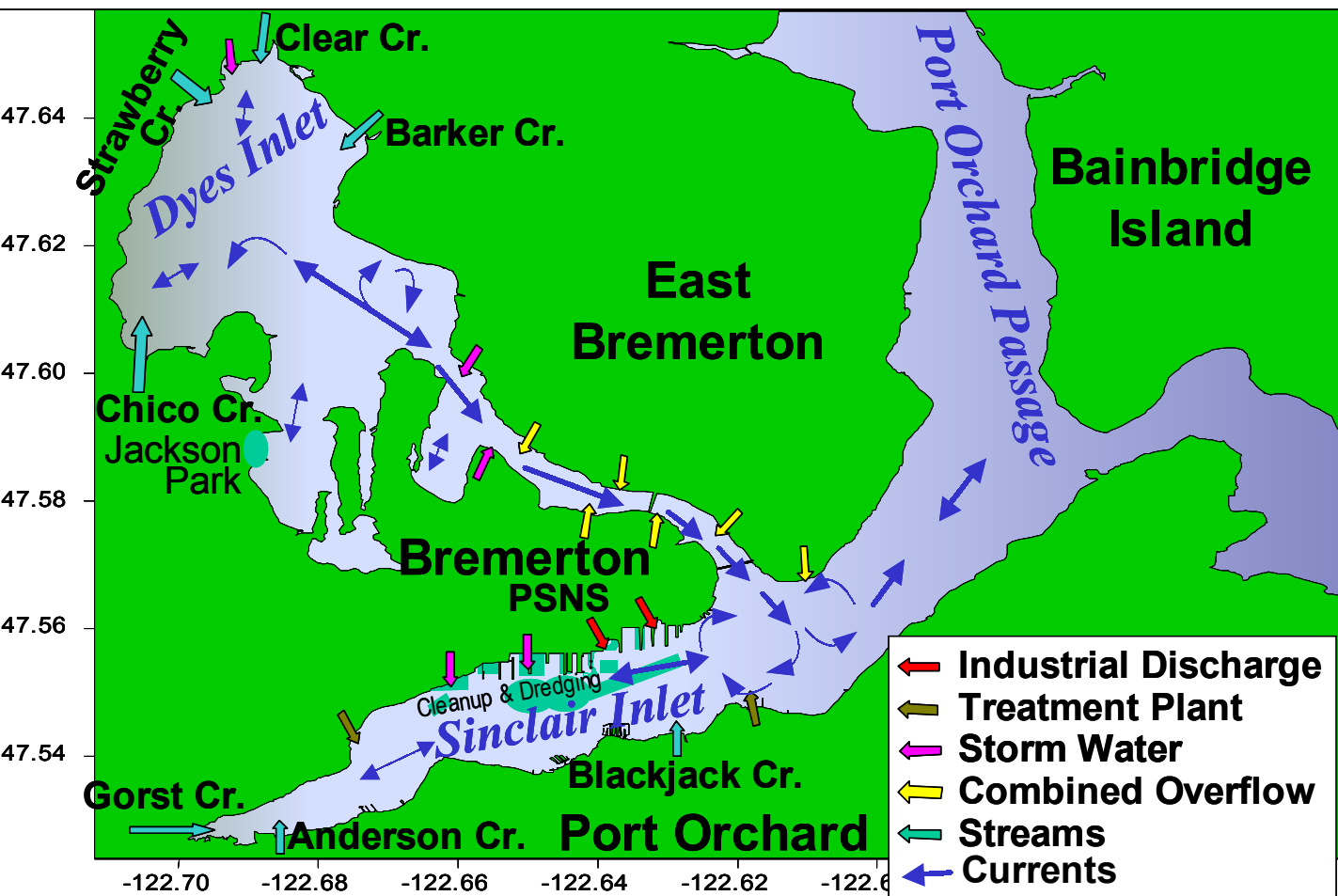


Figure 9. Conceptual model of major transport processes within the watershed.

Exposure Pathways

How can resources be harmed?

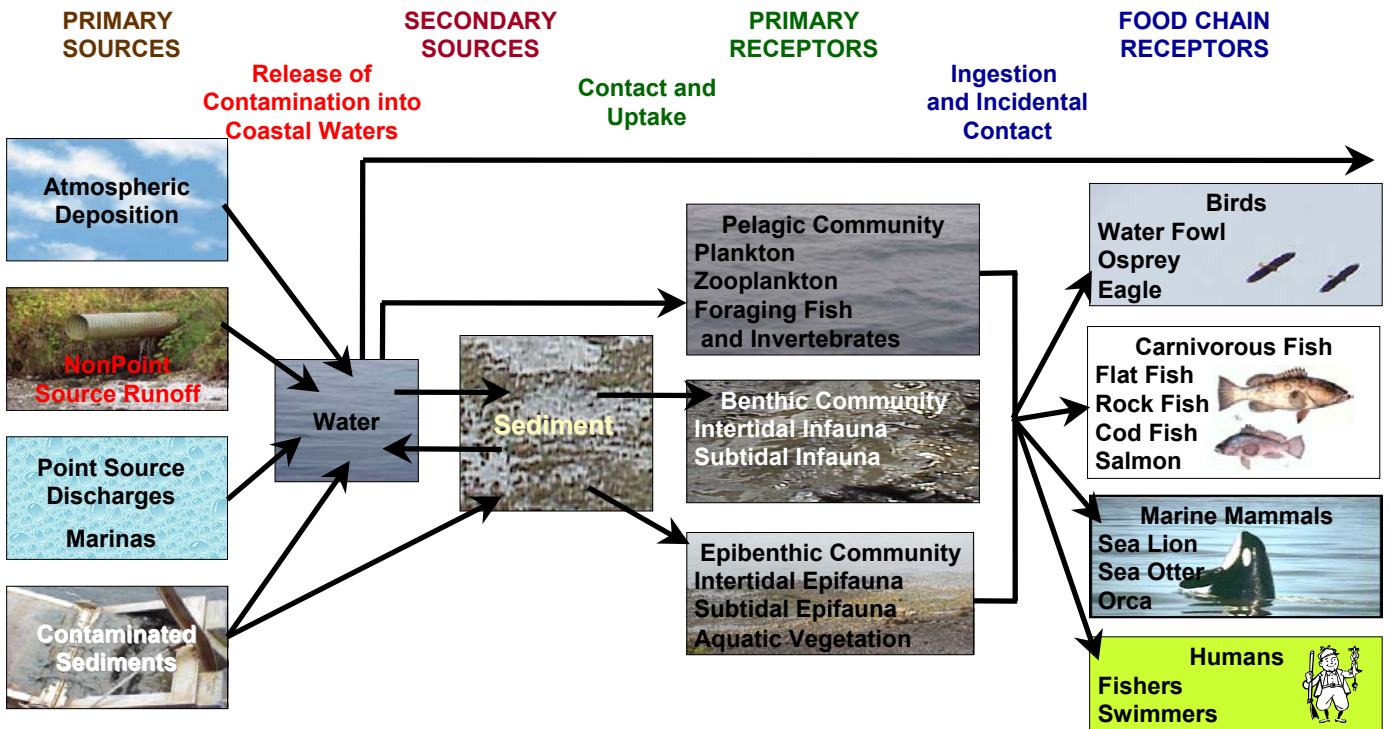


Figure 10. Exposure pathways indicate how sources of stress could harm components of the ecosystem (assessment endpoints) within Sinclair and Dyes Inlets.

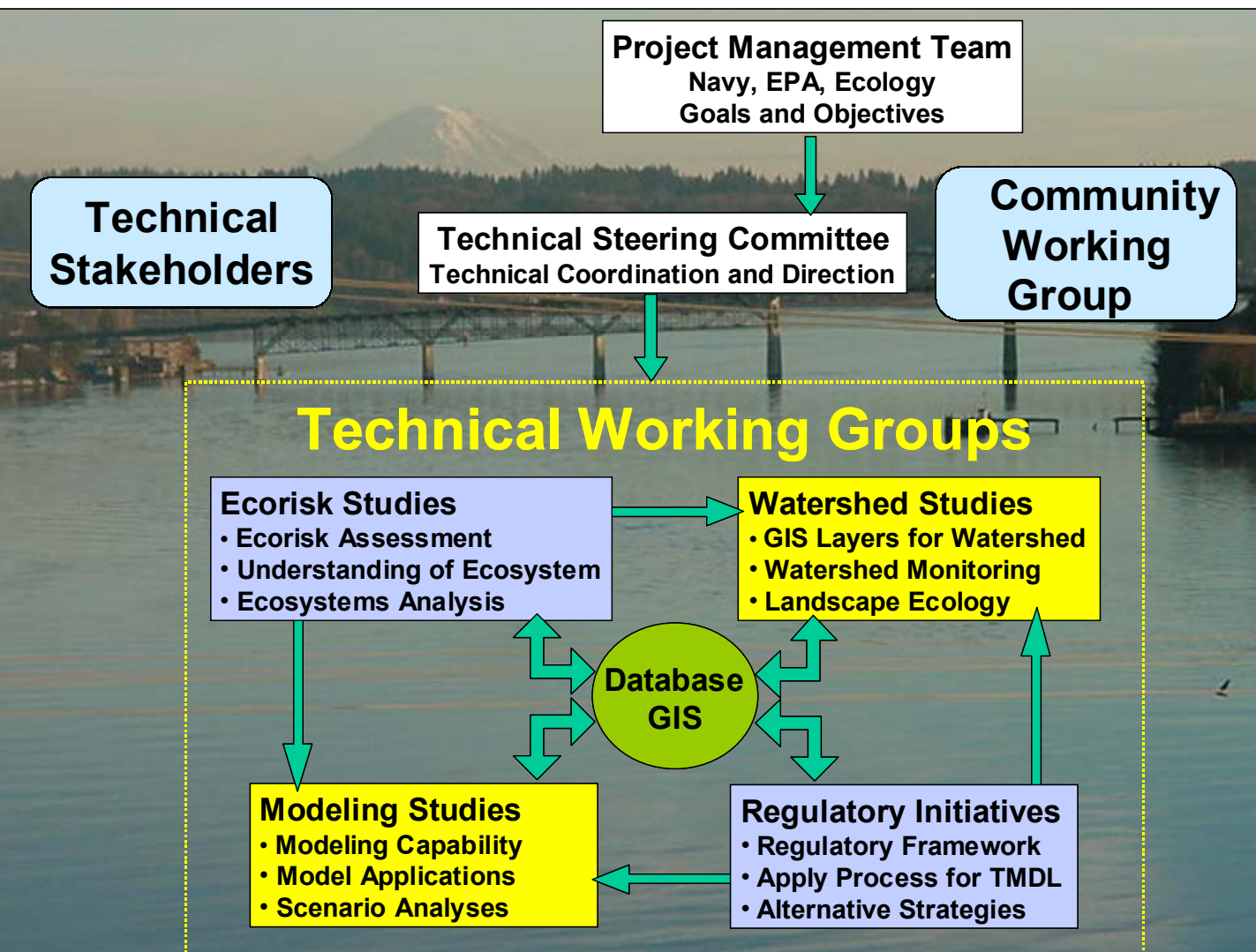
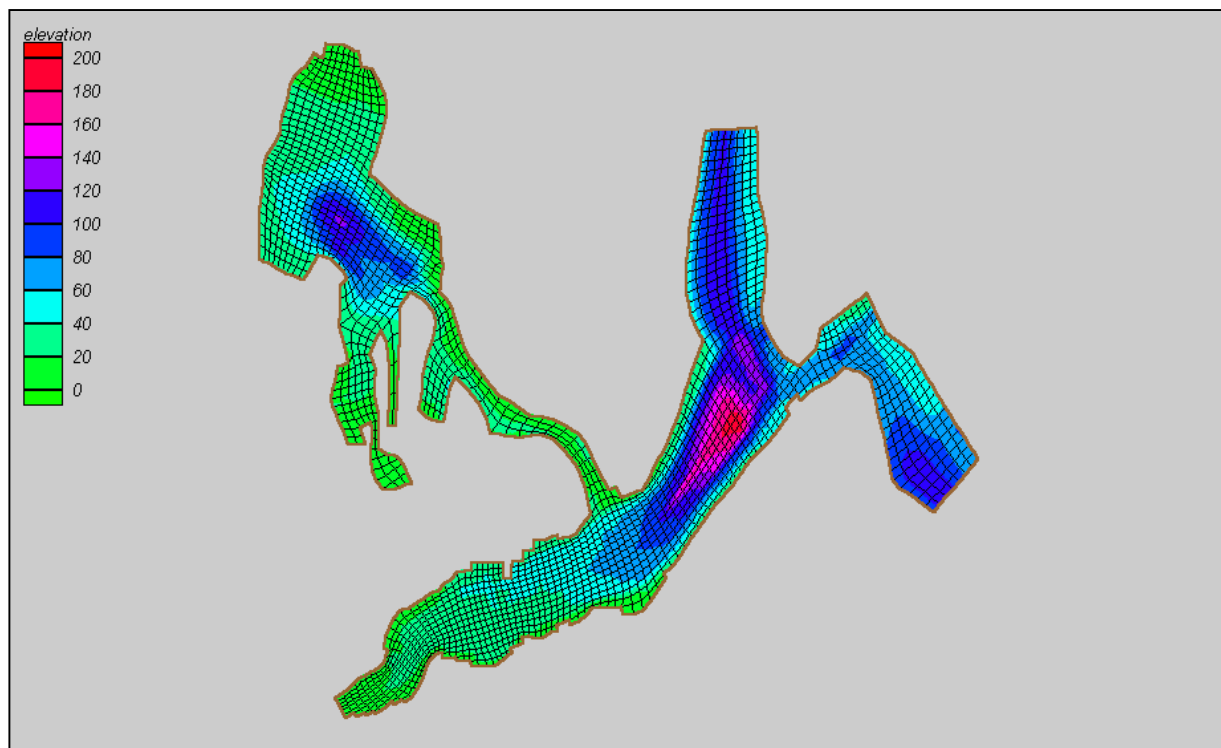


Figure 11. The project management structure and technical working groups formulated for the PSNS Project ENVVEST.

a. Computational grid for CH3D



b. A sample z-plane grid

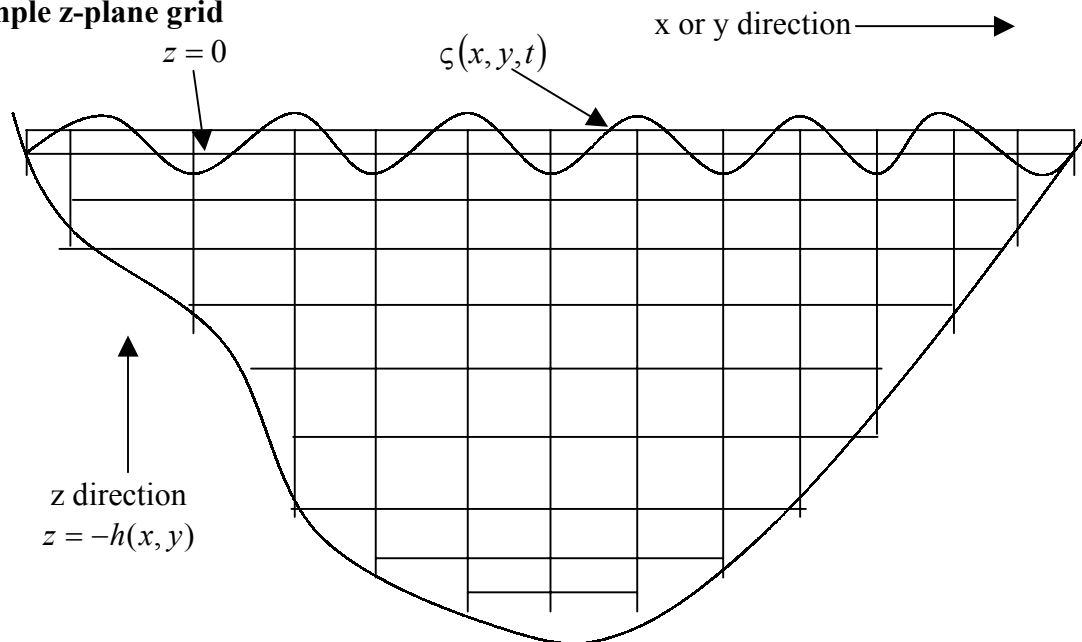
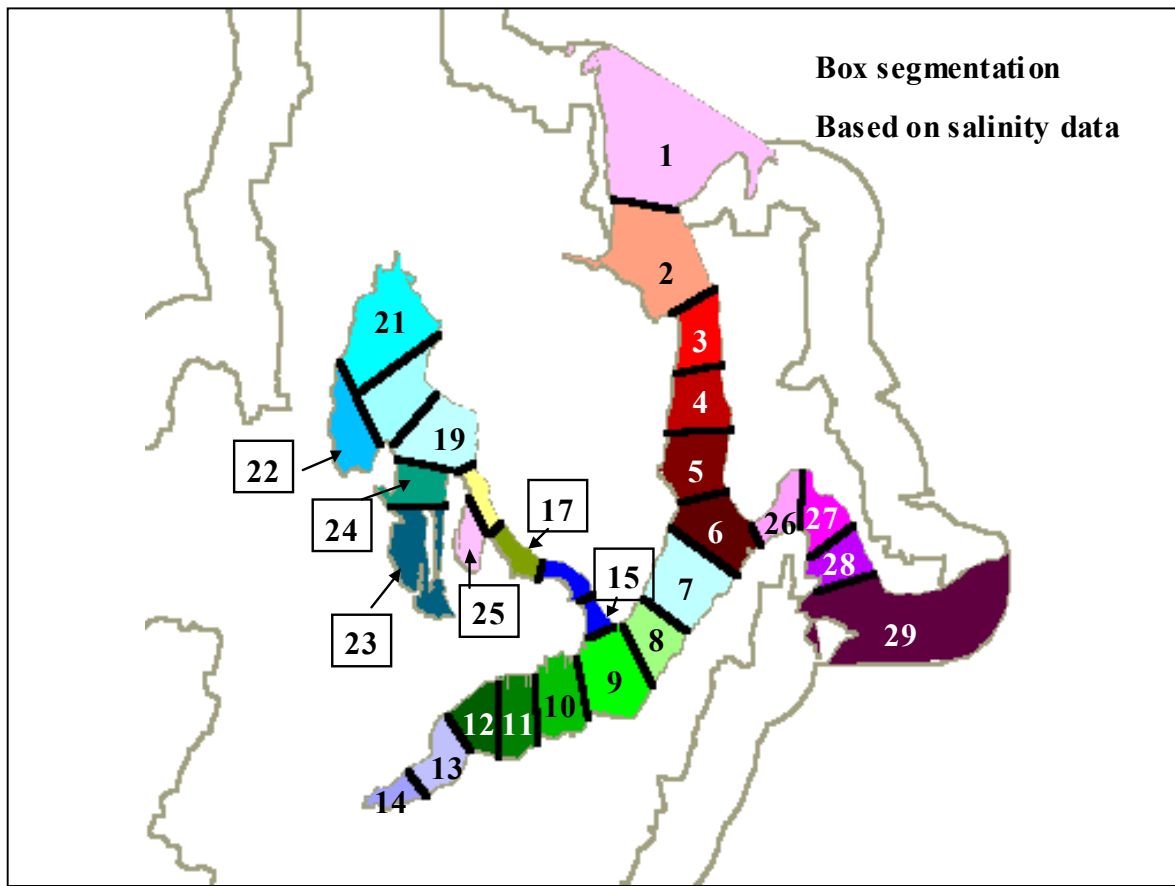


Figure 12. The computational grid (a) for CH3D consists of horizontal (91x96) and vertical boxes. A cross section of the inlet is shown (b). Note that from shore (either in the x or y direction), the number of cells used in the vertical, or z, direction varies in order to resolve the depth features of the inlet.

a. WASP box segments for the study area.



b. Conceptual diagram of WASP box model.

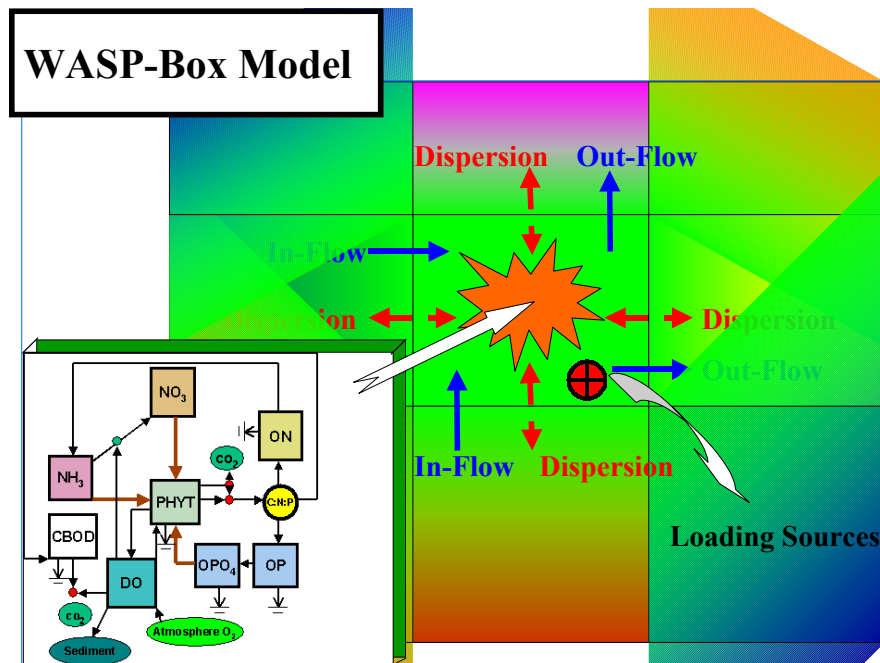


Figure 13. The box model configuration for WASP (a). Each box simulates in flow, out flow, and dispersion from adjoining boxes, loading sources if present, and the kinnetic processes being modeled (b).



Figure 14. Self-tracking drogues developed by SSC that were used to conduct current studies in Dyes Inlet.

Rocky Point, Group #3, 10/20/00

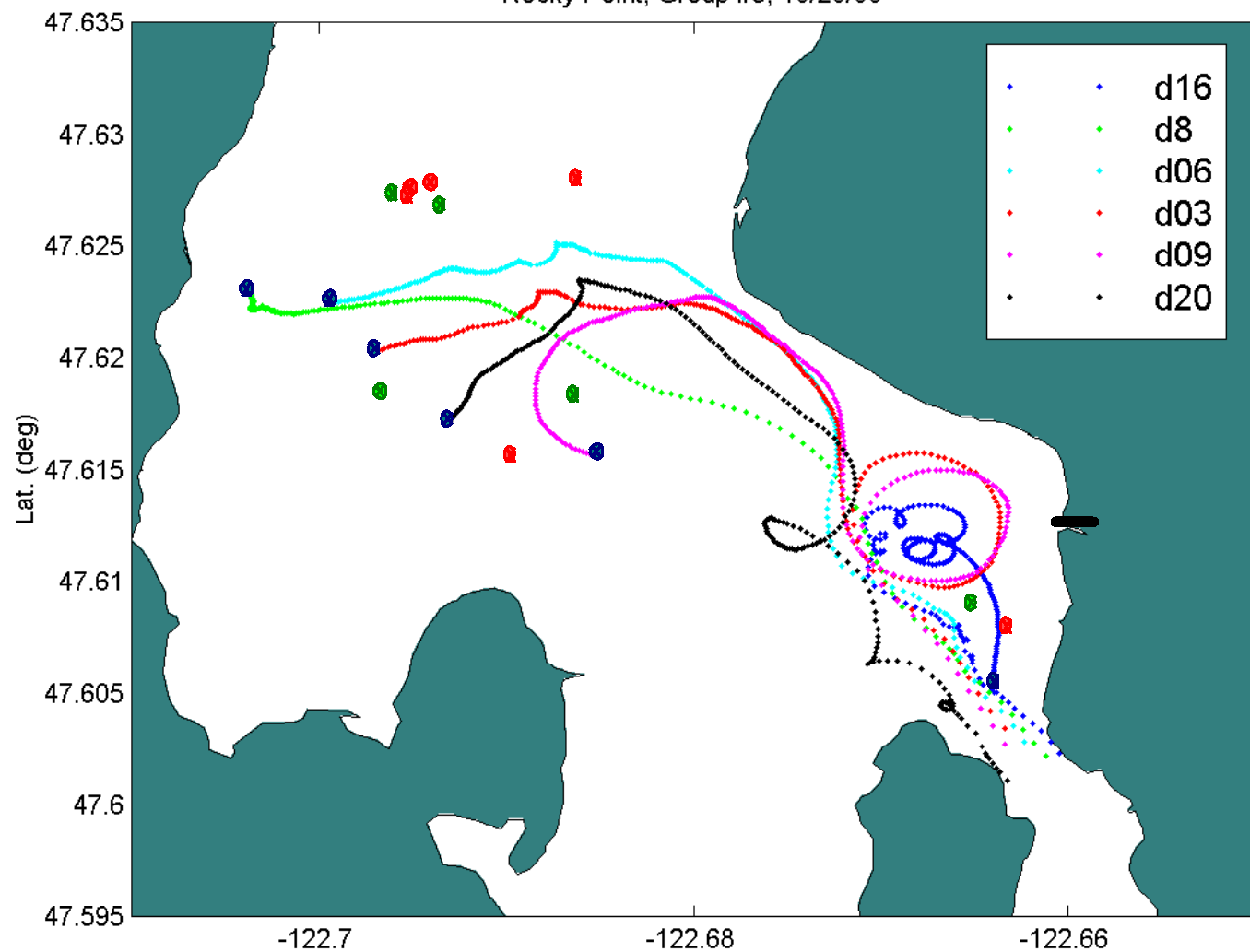


Figure 15. Cruise tracks of drogues released at Rocky Point on Oct. 20, 2001. Drogues were released at Rocky Point at max flood (red points), max flood +1 hr (green points), and max flood +2 hr (blue points and cruise tracks).

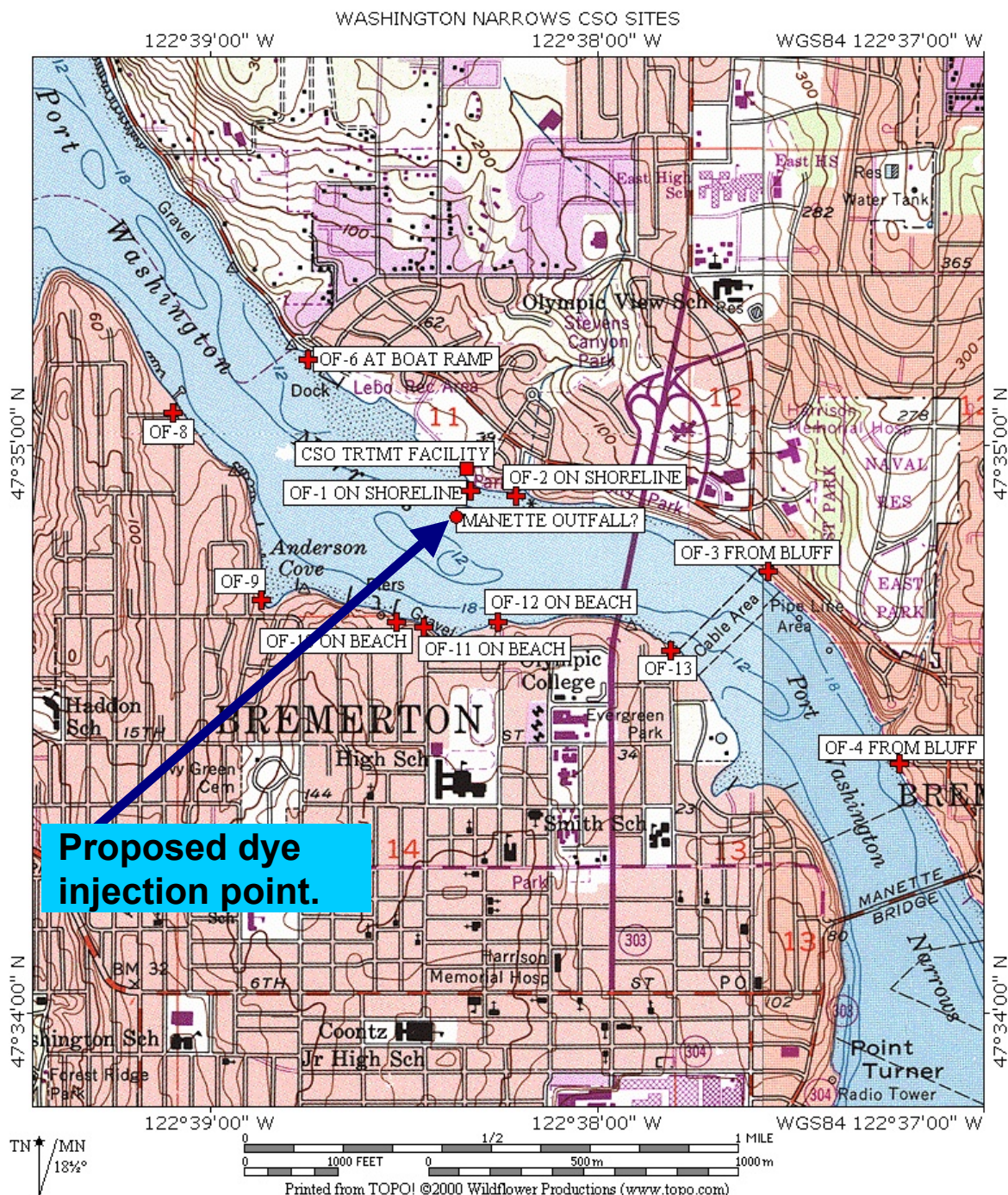
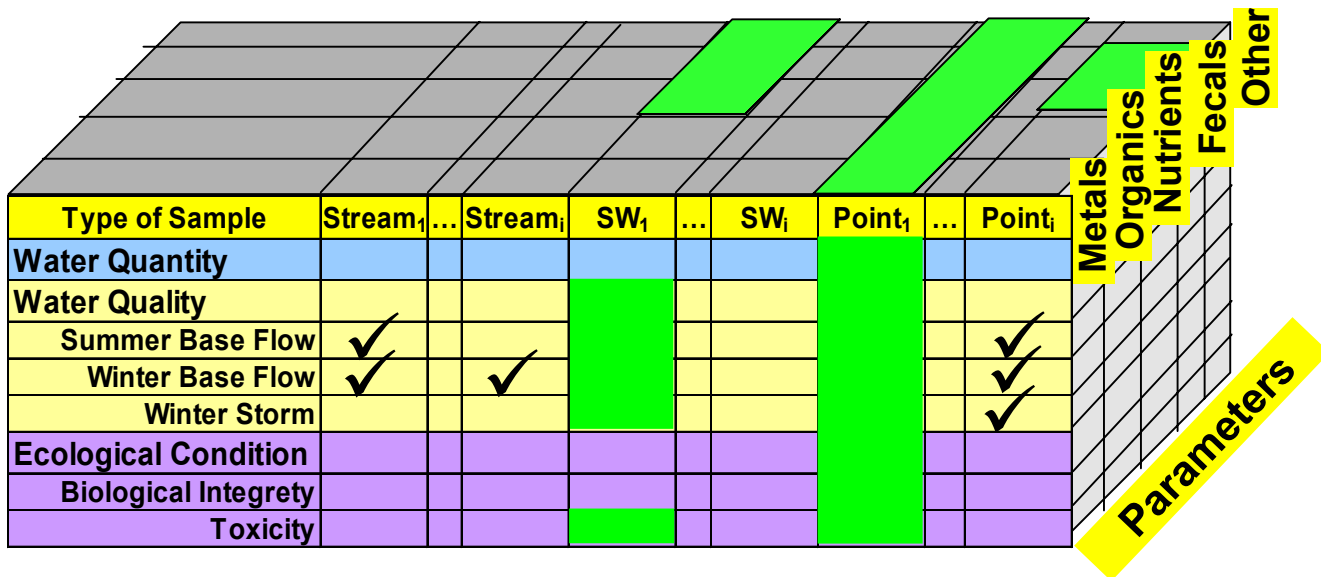


Figure 16. Location of combined sewer overflows (CSOs) in the Port Washington Narrows and the proposed point of dye injection for the simulated CSO study and model validation.



Bremerton Kitsap Health District
 City of Bremerton
 Department of Health
 Kitsap County
 Kitsap Public Utilities District
 Navy / EPA / Ecology
 Suquamish Tribe
 (Other TBD)

Figure 17. Conceptual approach for developing a cooperative watershed monitoring program.

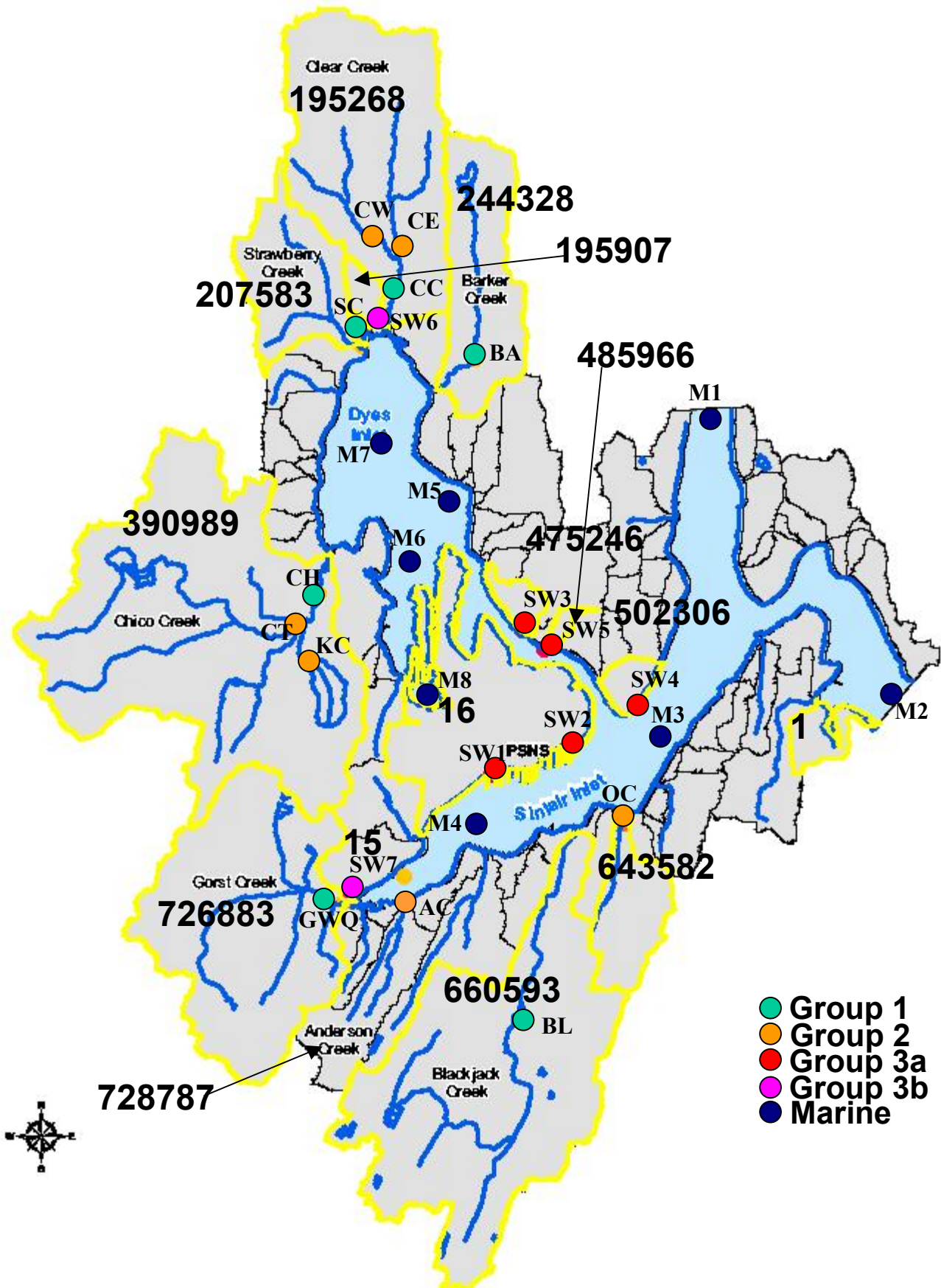


Figure 18. Proposed locations for streams (Groups 1 and 2), storm water outfalls (Groups 3a and 3b), marine stations and the watershed id (numbers) for the watershed monitoring program.



Parameter	Units
Local Time	hours
Latitude	degrees
Longitude	degrees
Ship Velocity	$\text{m}\cdot\text{s}^{-1}$
Relative Wind Velocity	degrees, $\text{m}\cdot\text{s}^{-1}$
Current Velocity (full water column)	degrees, $\text{m}\cdot\text{s}^{-1}$
Sample Pressure	decibars
Conductivity	$\text{siemens}\cdot\text{m}^{-1}$
Temperature	degrees centigrade
Bottom Depth	m
Light Transmission	Percent
pH	NBS
Dissolved Oxygen	$\text{mL}\cdot\text{L}^{-1}$
Oil fluorescence	relative volts
Chlorophyll fluorescence	relative volts
Nutrients	
NO_3 , NO_2 , NH_3 , PO_4 , SiO_2	$\text{mg}\cdot\text{L}^{-1}$
Metals	
Cu, Pb, Cd, As, Ag, Se, Zn, Cr	$\mu\text{g}\cdot\text{L}^{-1}$

Figure 19. The R/V ECOS and the Marine Environmental Survey Capability used to conduct water quality assessments in Sinclair and Dyes Inlet.

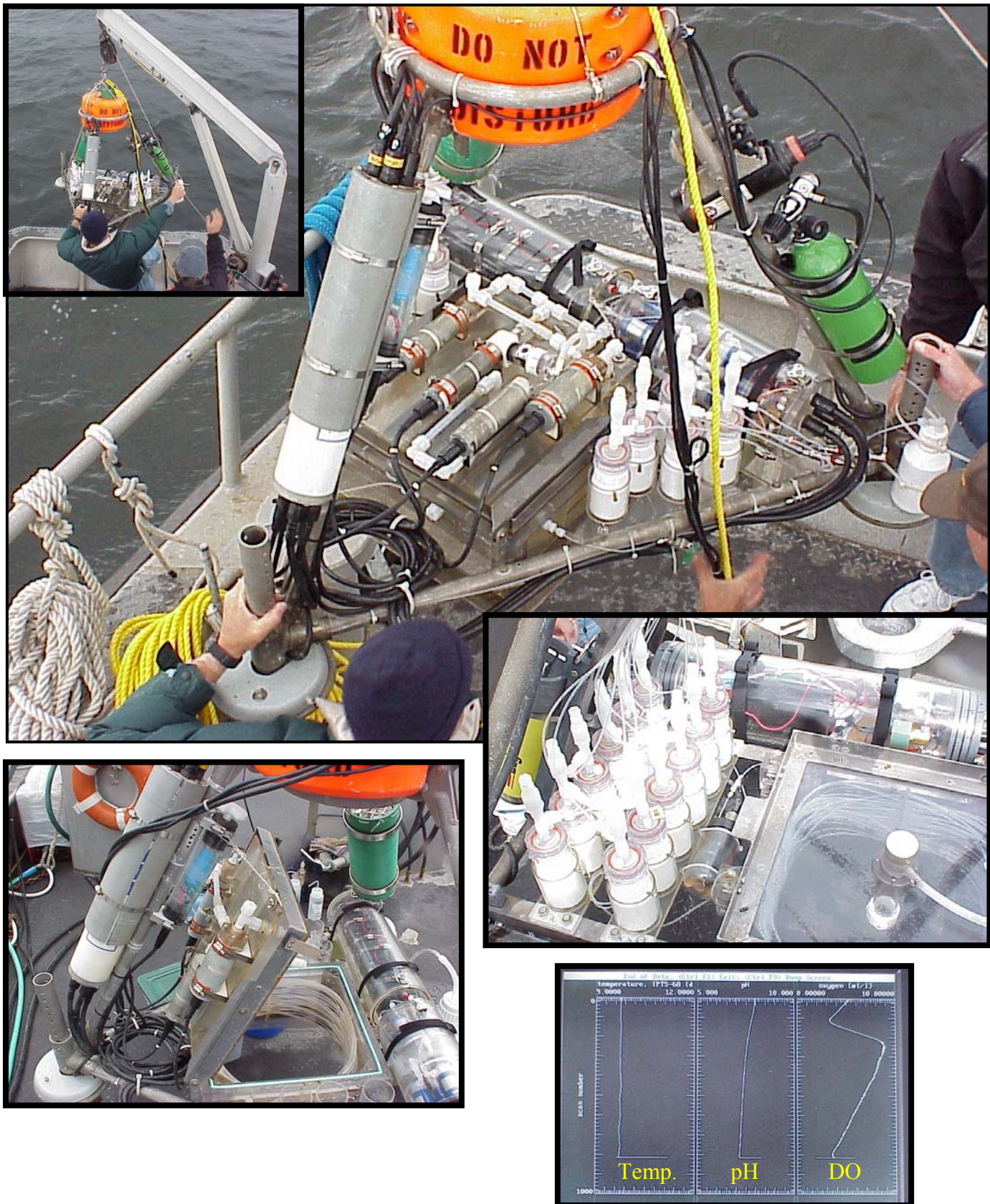


Figure 20. The Benthic Flux Sampling Device (BFSD) used to measure *in situ* flux of contaminants from Sinclair and Dyes Inlets.

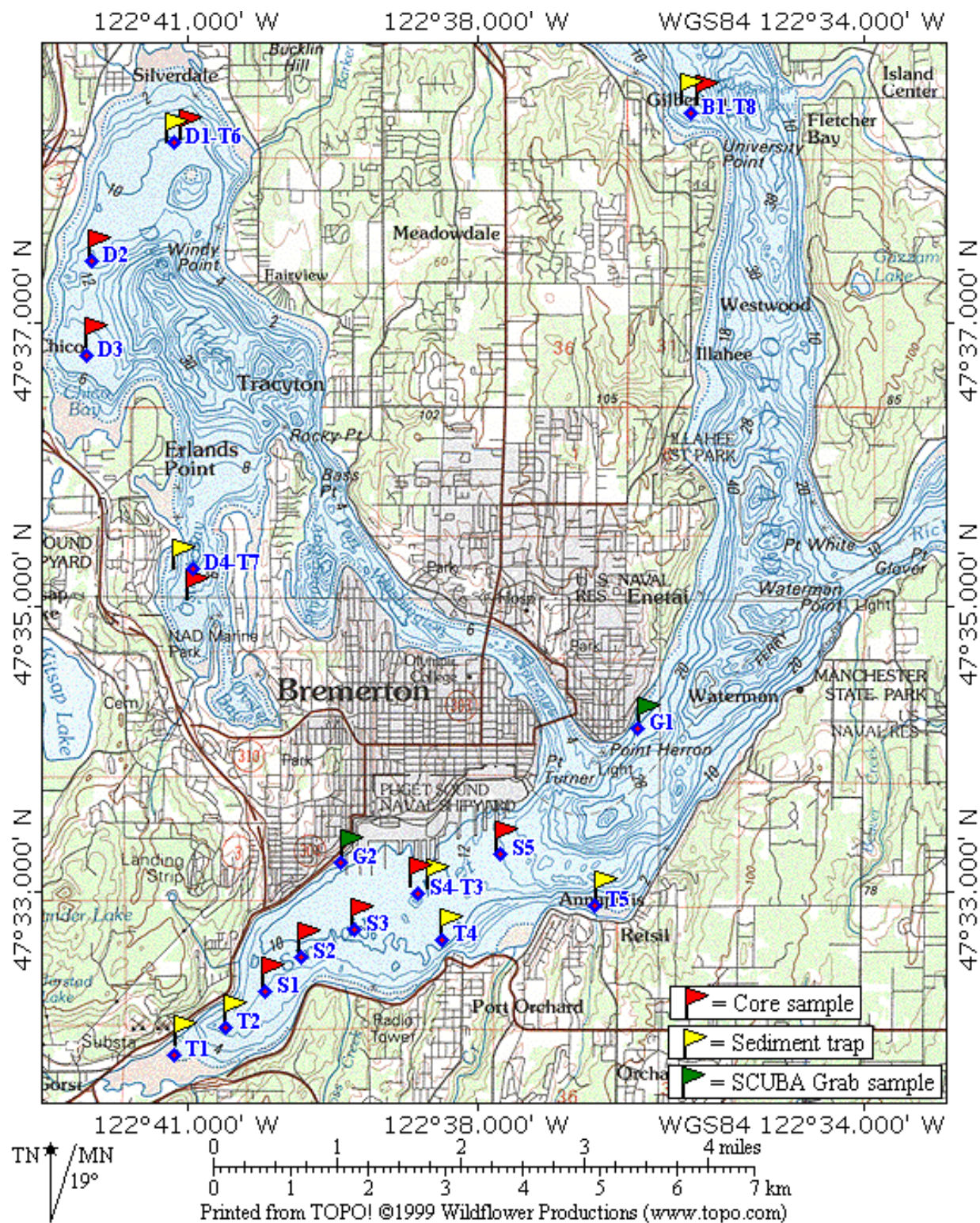


Figure 21. Proposed sample locations for cores (red flags), sediment traps (yellow flags), and grabs (yellow flags) to be collected for the sediment mass balance study (Miller et al. 2002). Additional grabs will be collected in depositional areas located near major stream and storm water deltas (not shown).

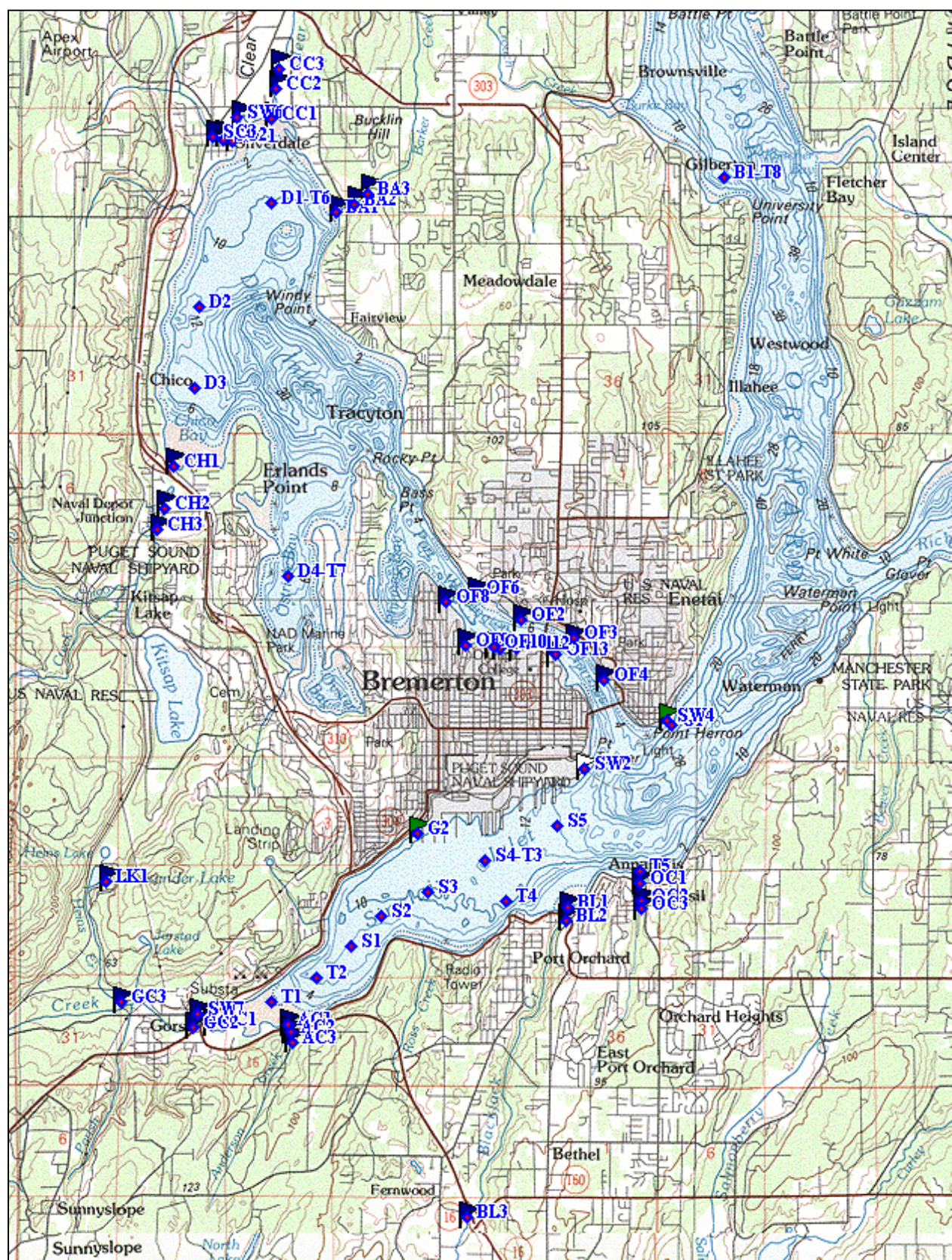


Figure 22. Proposed sample locations for grab samples of fluvial deposit (black flags) associated with major streams and storm water outfalls.,

Ecopath model: Open ocean

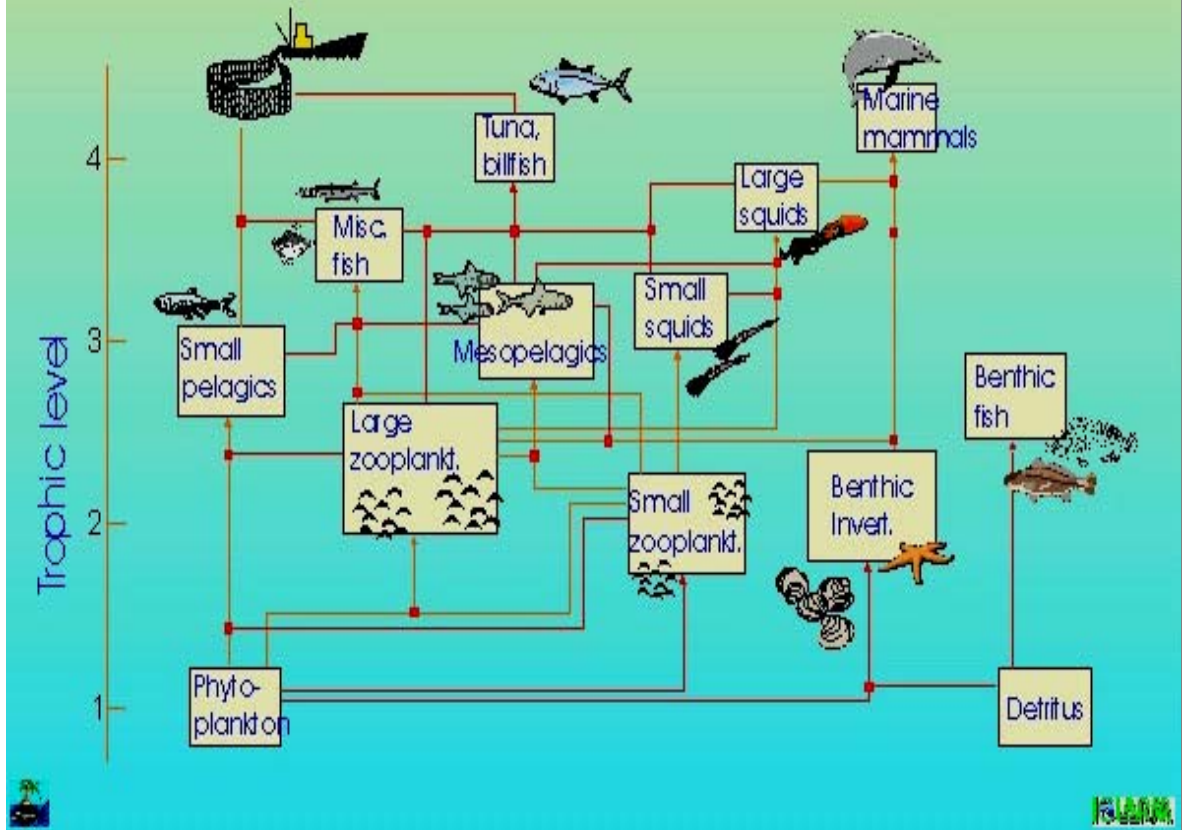


Figure 23. Conceptual diagram of an Ecopath model for an open ocean ecosystem (from Pauly, Christensen, and Walters 1999).

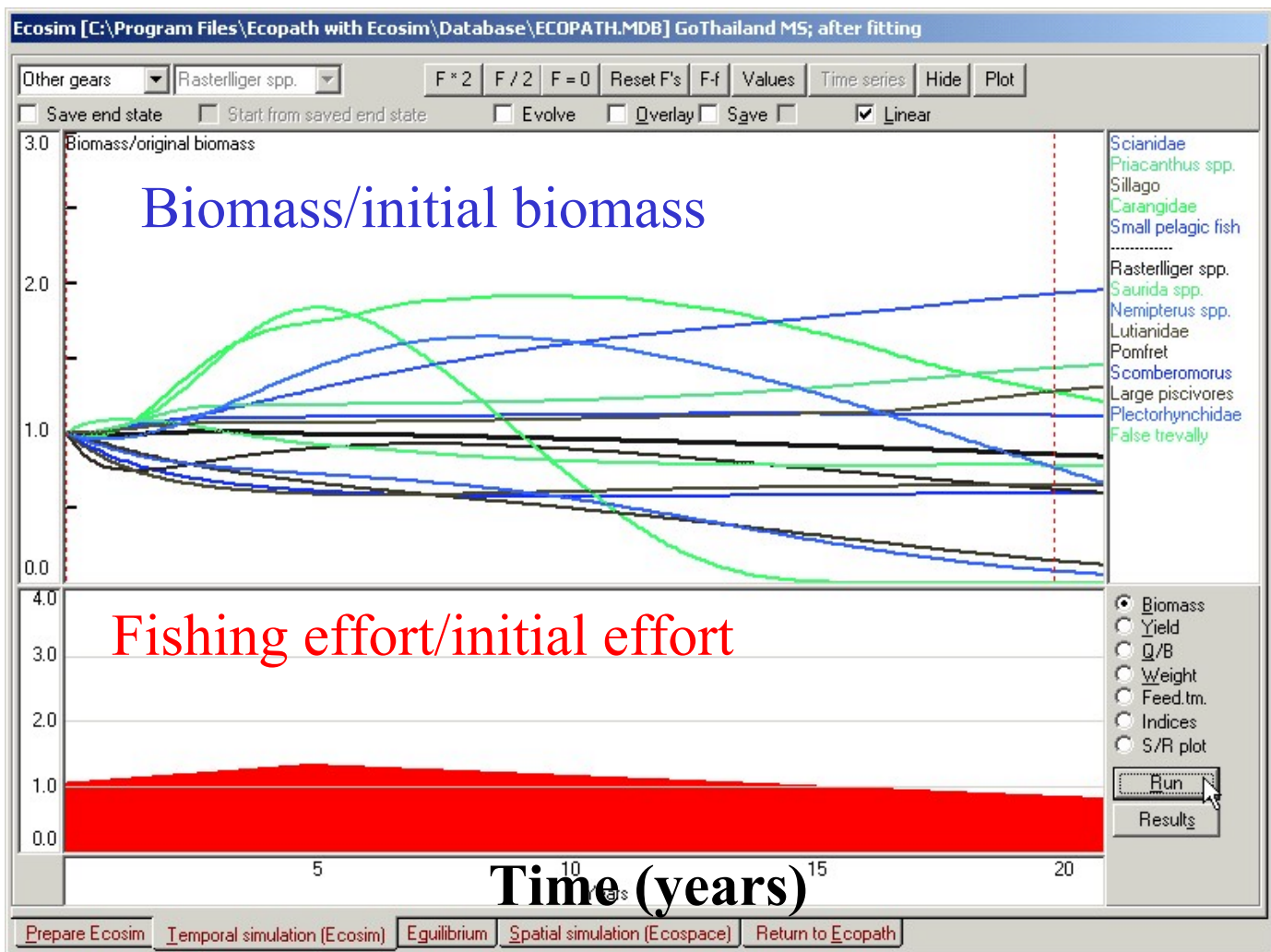


Figure 24. Example output of an Ecosim model developed to assess ecosystem response to a coastal fishery (Fisheries Centre 2001).

7. Plan of Action and Milestones and Work Breakdown Structure

7.1 Regulatory Studies

Milestone	Date	
TMDL Studies		
TMDL Scope	Jun 2002 Draft	Aug 2002 Final
TMDL Study Plans		
Fecal Coliform	Jun 2002 Draft	Aug 2002 Final
Copper/Metals	Sep 2002 Draft	Nov 2002 Final
Other	TBD	
Waste Load and Load Allocations	TBD	
Implementation Plan	TBD	
Monitoring Plan	TBD	
Regulatory Framework		
Regulatory Framework Report	Jun 2002 Draft	
TMDL Case Study Report	Feb 2002 Draft	
Web-Based Regulatory information clearing house	Feb 2002 Draft	
Alternative Scenarios		
Procedure for Proposing Alternatives	Sep 2004	
Alternative Proposal(s)	TBD	

Regulatory Studies																	
Year		2000				2001				2002				2003			
Quarter		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Define Regulatory Framework																	
Apply TMDL Process for Watershed																	
Alternative Strategies																	
Completed																	
Planned																	
Milestones																	
Recommendations																	

7.2 Modeling Studies

Milestone	Date
Develop Modeling Capability	
HSPF Models	
Watershed Calibration and Verification Plan	July 2001 Draft
Calibrated for Hydrology	Aug 2001
Calibrated for Water Quality	Aug 2003
Verified Watershed Model	Aug 2004
SWMM Models	Jan 2002
Setup	Aug 2001
Calibration/Verification	Sep 2003
CH3D	
Calibrated/Verified for Hydrodynamics	Dec 2001
WASP (Box Model)	Dec 2001
Integrated with CH3D	Jun 2002
Model Applications	
CSO Modeling Study (CH3D-FC)	Sep 2002 Draft
TMDL Modeling Study	
Fecal Coliform	Mar 2003 Draft
Copper/Metal	Sep 2003 Draft
Other	TBD
Scenario Simulation	TBD

Modeling Studies																			
Year		2000				2001				2002				2003					
Quarter		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4		
Develop Modeling Capability																			
Model Applications																			
CSO Impact on Shellfish Beds																			
Modeling for TMDL																			
Scenario Simulation																			
Completed																			
Planned																			
Milestones																			
Recommendations																			

7.3 Watershed Studies

Milestone		
Develop GIS Layers for Watershed	Ongoing	
Watershed Monitoring	Start	Complete
Initiate Hydrologic and Meteorological Monitoring	Jan 2001	Dec 2004
Initiate Water Quality Base Flow Monitoring	Mar 2002	Dec 2004
Water Quality Storm Event Monitoring	Sep 2002	Dec 2004
Ecological Condition	Sep 2000	Dec 2004
Landscape Ecology		
Relative flows for Subwatersheds	Jun 2002 Draft	Sep 2004 Final
Estimate Water Quality as a Function of Land Use	Sep 2002 Draft	Sep 2004 Final
Coordination with Chico Futures Project	Ongoing	

Watershed Studies																	
Year		2000				2001				2002				2003			
Quarter		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Develop GIS Layers																	
Watershed Monitoring																	
Landscape Ecology																	
Completed																	
Planned																	
Milestones																	
Recommendations																	

7.4 Ecological Studies and Risk Assessment

Milestone		
Ecological Risk Assessment (NOTE: Ecorisk tasks on hold pending completion of TMDL Study Plan and Watershed Monitoring Plan)		
Problem Formulation		
Screening Level Risk Assessment		
Develop Ecorisk Data Gap Monitoring Plan		
Baseline Risk Assessment		
Long Term Monitoring and Risk Verification		
	Start	Complete
Develop Understanding of Ecological System		
Baseline Water Quality Surveys	Sep 1997	Sep 2000
Baseline Benthic Flux Assessment	May 2000	Jun 2002
Contaminant Mass Balance for Sediment	Mar 2002	Sep 2004
Evaluation of Fluvial Deposits	Mar 2002	Sep 2003
Ecological Systems Analysis		
Develop Approach for Systems Level Analysis	TBD	
Implement Systems Level Analysis	TBD	

Ecorisk Studies																	
Year		2000				2001				2002				2003			
Quarter		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Ecological Risk Assessment																	
Understand Ecosystem																	
Ecological Systems Analysis																	
Completed																	
Planned																	
Milestones																	
Recommendations																	

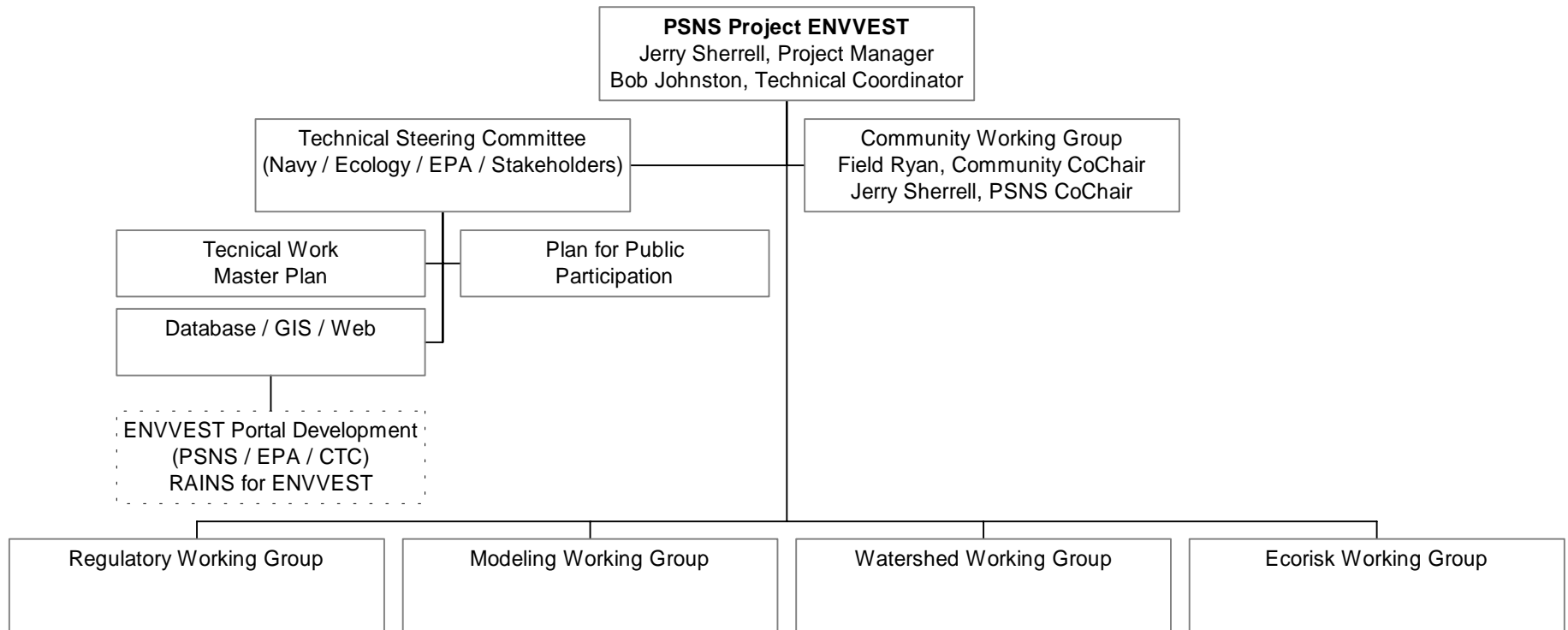


Figure 7-1. Work breakdown structure for PSNS Project ENVVEST.

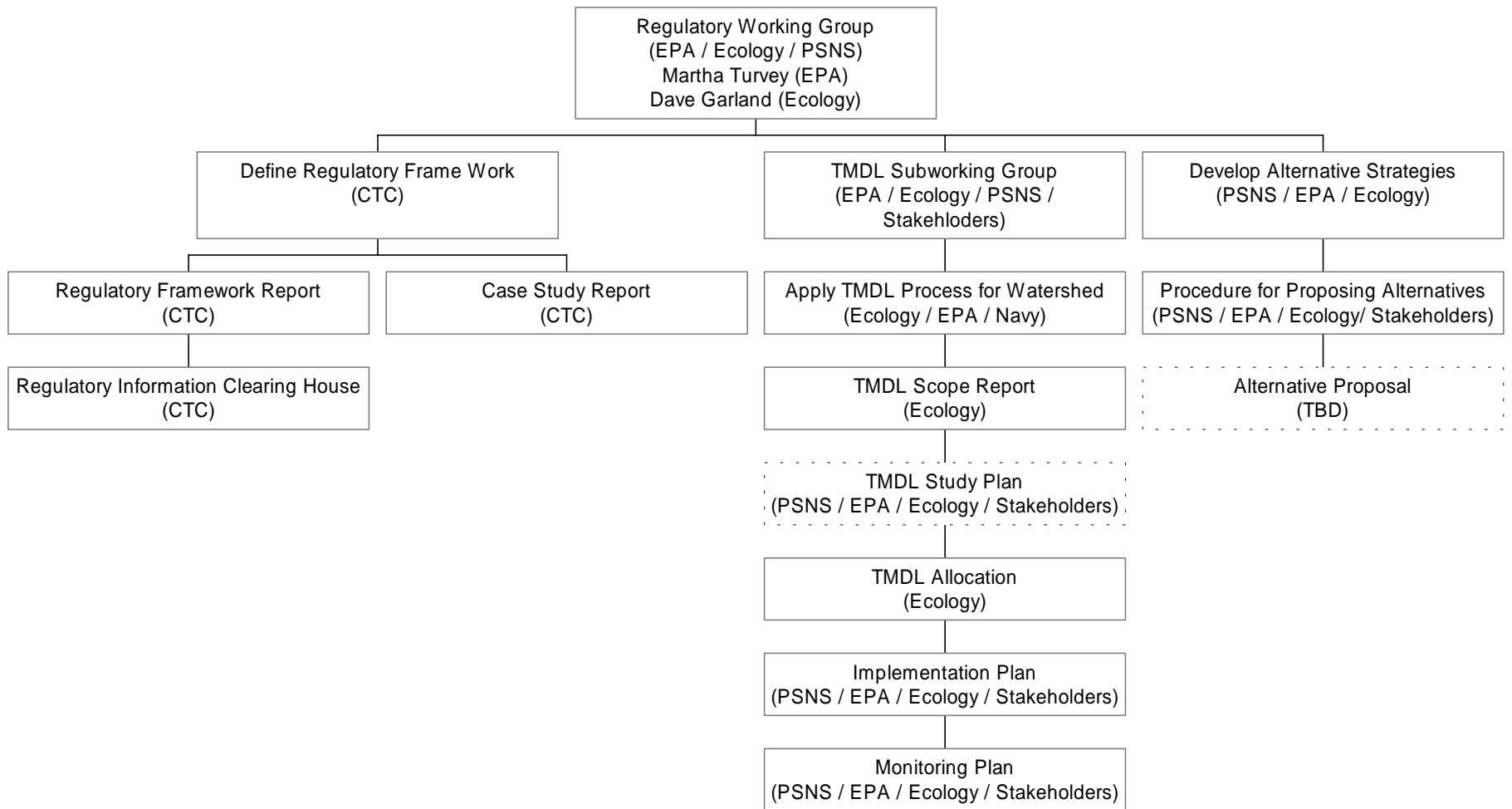


Figure 7-2. Work breakdown structure for the Regulatory Working Group.

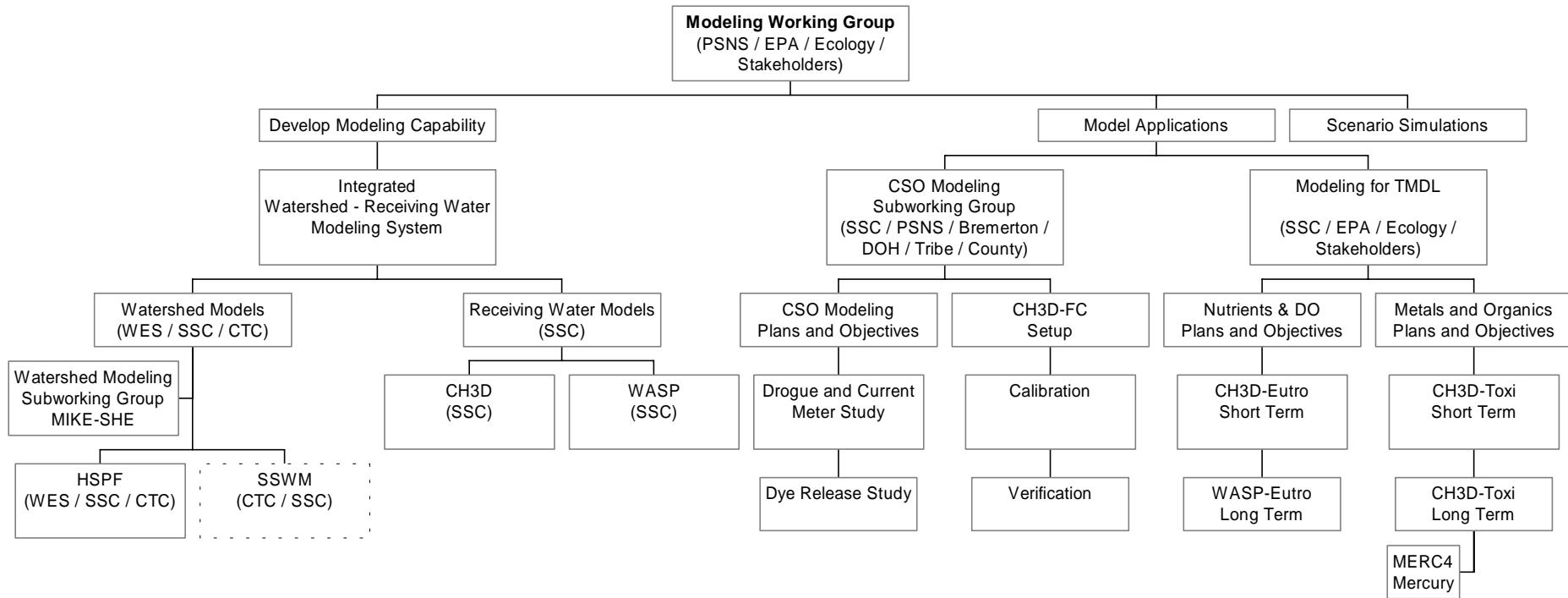


Figure 7-3. Work breakdown structure for the Modeling Working Group.

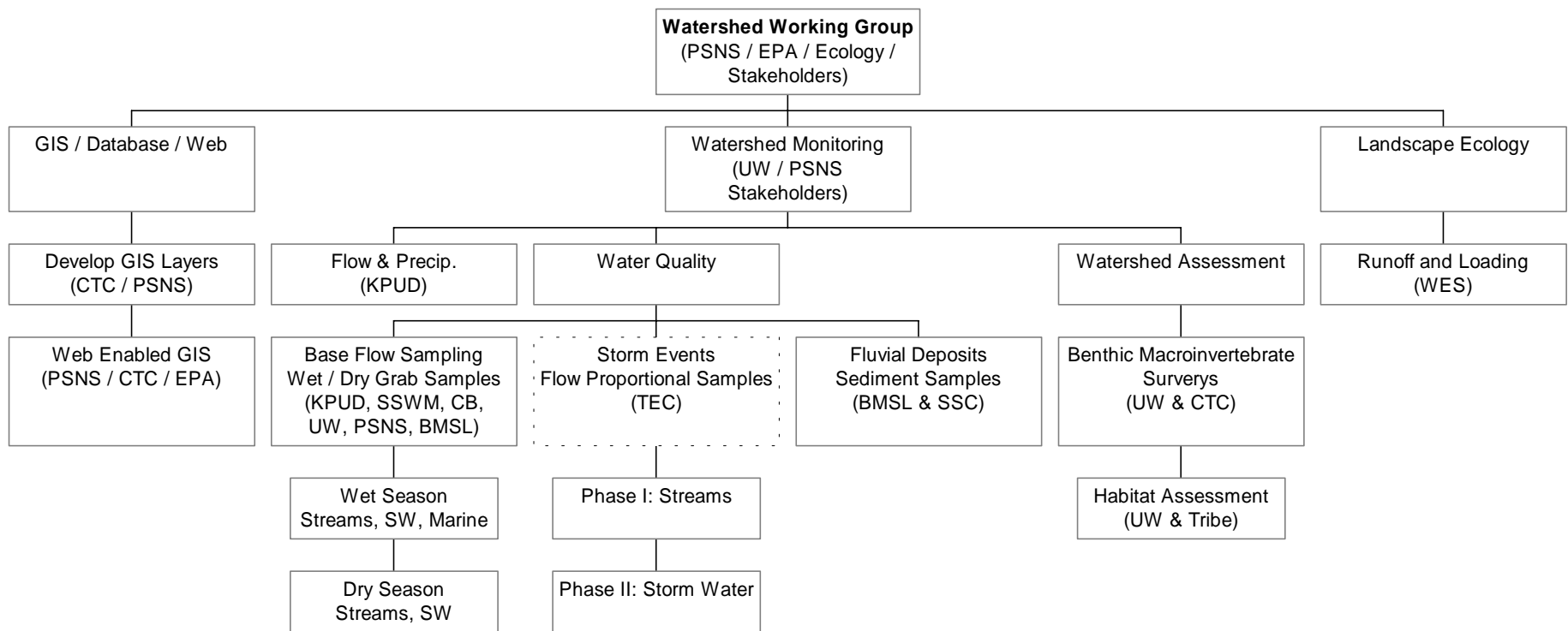


Figure 7-4. Work breakdown structure for the Watershed Working Group

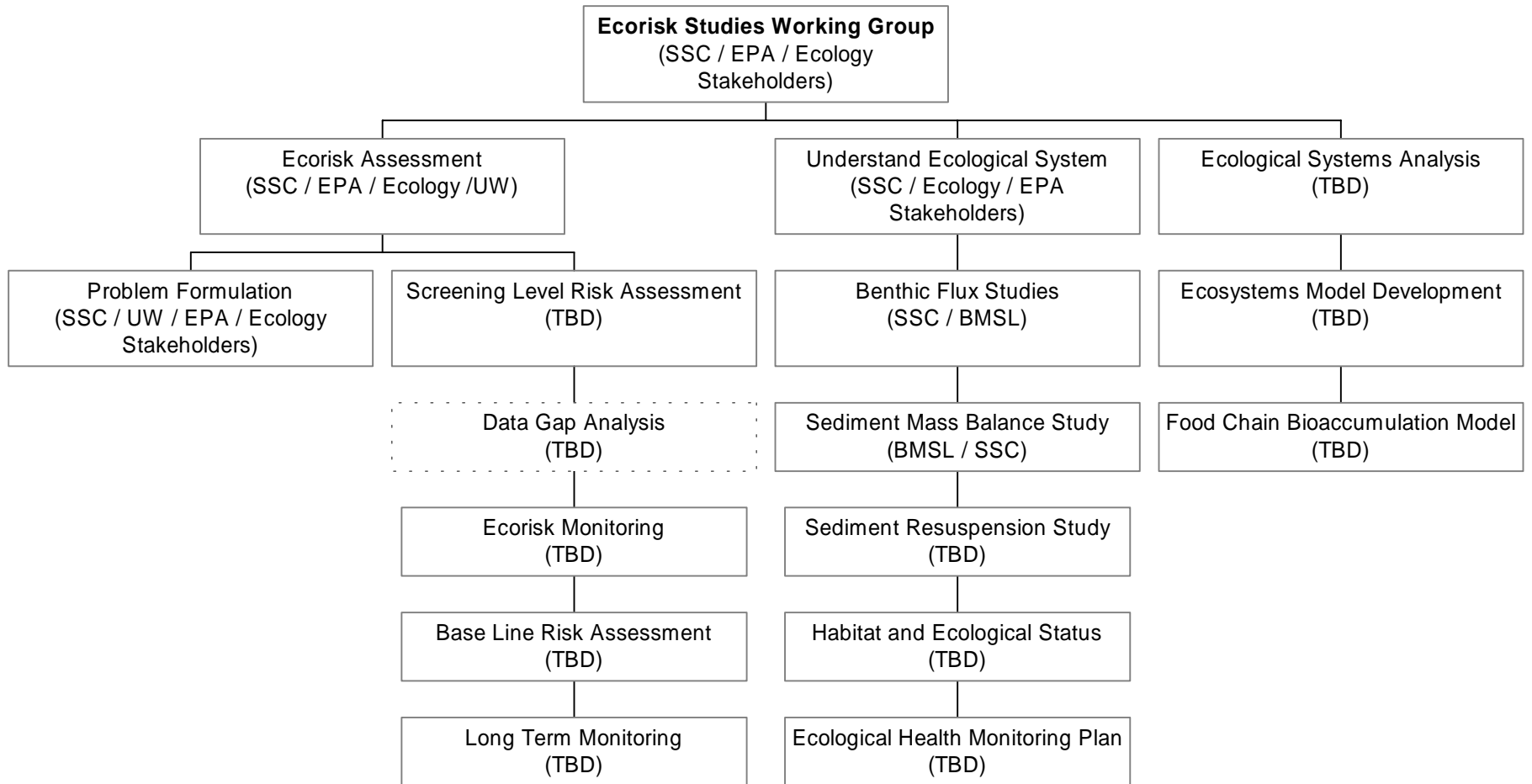


Figure 7-5. Work breakdown structure for the Ecorisk Studies Working Group.

8. Status and Progress of Technical Working Groups

8.1 Project Management Team

[March 13, 2001](#)

May 11, 2001 Defined goals, objectives and “ground rules” for Project; endorsed technical working groups (Regulatory/Ecorisk and Modeling/Watershed).

[July 27, 2001](#)

[Oct 18, 2001 ENVVEST 1 Year Later](#)

8.2 Technical Steering Committee

[April 4, 2000](#)

[May 3, 2001](#)

[May 17, 2001](#)

[June 28, 2001](#)

October 4, 2001 [March 29, 2002](#) [April 23, 2002](#)

Products

[A Watershed-based Ecological Risk Assessment for Sinclair Inlet, Washington](#) (Feb 2001)

Technical Work Master Plan (Draft March 2001)

[A Process to Foster Stakeholder Involvement and Participation in Watershed Management: Experiences from the PSNS ENVVEST Project.](#) (April 2001)

Technical Work Master Plan (Revised Draft October 2001)

Technical Work Master Plan (Review Draft April 2002)

Plan for Community Involvement (under development, Draft September 2001, Navy/EPA/Ecology/Kitsap County)

[Achieving Effective and Efficient Compliance through Watershed-Based Assessment and Partnering: Experiences from PSNS Project ENVVEST](#) (December 2001)

8.3 Regulatory & Ecorisk Working Group

[August 20, 2000](#) (Project Kickoff)

[September 21, 2000](#)

[May 31, 2001](#)

October 29, 2001

Products

Water Quality Monitoring

ECOS Survey Report

Sediment Quality Monitoring (in prep)

Ecorisk Problem Formulation (in prep, Navy/EPA have lead)

Ecological Studies Reports

[Water Quality Surveys](#)

[Benthic Flux Study](#)

[Sediment Mass Balance Study](#) QAPjP (Miller et al. 2002) FSAP, HASP

8.3.1 TMDL Subworking Group

Aug 8, 2001

Products

TMDL Charge and Direction (incorporated into Master Plan)

TMDL Study Plan (in prep, Ecology/EPA have lead)

8.4 Modeling and Watershed Monitoring Working Group

[October 26-27, 2000](#)

[December 7, 2000](#)

[January 30 - February 1, 2001](#)

[August 29-30, 2001](#) May 14, 2002 AWRA Spring Speciality Conference

Products

[A Hydrodynamic Modeling Study Using CH3D for Sinclair Inlet](#), (Nov 1999)

[Dispersion resulting from aggregating hydrodynamic properties in water quality modeling](#) (Wang, P.F. 2001).

[CH3D Users Manual \(Draft July 2001\)](#)

[Watershed Model Calibration and Verification Plan](#) (in review, Navy has lead)

Watershed Models (under development)

HSPF ([Clear](#), [Barker](#), [Strawberry](#), [Chico](#), [Gorst](#), [Blackjack](#), and [Anderson](#))

[MIKE-SHE](#) ([Chico Creek](#) partnership with Kitsap County)

Surface Water Models

Shortterm (days – weeks) CH3D

[CH3D Users Manual](#)

Longterm (months – years) WASP

Status of Models			
Model	Setup	Calibrated	Verified
HSPF - Clear, Barker, Stawberry	X	X (Hydrology)	
HSPF - Gorst, Blackjack	X	X (Hydrology)	
HSPF - Chico	X	X (Hydrology)	
HSPF - Anderson (Intercal)	X		
MIKE-SHE - Chico	X	Initial	
CH3D – tides & currents	X	X	X
CH3D-Eutro – nutrients & DO	X		

CH3D-FC – fecal coliform	X	Initial	
CH3D-Toxi – contaminants	X		
WASP-Eutro – nutrients & DO	X		
WASP-Toxi – contaminants	X		

Watershed Monitoring Plan (in prep)

GIS Layers (in prep)

[GIS Watershed Assessment Plan](#)

[Neural Network Analysis for Watershed Modeling](#)

Watershed Monitoring

Stream Flow – stream gaging stations established for six locations – (partnering with KPUD)

Ecological Condition – baseline

Water Quality Monitoring Plan (under development)

8.4.1 Watershed Modeling Subworking Group

May 2001

Products

[Develop watershed models for Chico Creek](#) (Partnering with Kitsap County, Danish Hydrologic Institute, and Watershed Council)

8.4.2 CSO Modeling Subworking Group

October 2000 ([Drogue and Current Meter Study Plan](#))

February 2, 2001

September 27, 2001

October 24, 2001

March 10-13, 2001 (Dye Release Study)

Products

[Drogue & Current Meter Study](#)

[Lagrangian Drifts in the Tide and Wind-Driven Dyes Inlet, WA](#) (June 2001)

[Model for Simulating CSO Discharges in Port Washington Narrows](#)

[CSO Model Verification with Dye Release Study](#)

(Partnering with City of Bremerton, Department of Health, Suquamish Tribe, Kitsap County) - [Preliminary Results from Dye Study](#)

8.5 Database/GIS Core Capability

[Functional Specification for Access to Information & Data](#) (June 2000)

Portal Demonstration and Implementation (on going)

RAINS Portal for ENVVEST (in development)

[8.6_Community_Working_Group](#)

9. Products and Reports

9.1 Regulatory Studies

[A Watershed-based Ecological Risk Assessment for Sinclair Inlet, Washington](#) (Feb 01)

[A Process to Foster Stakeholder Involvement and Participation in Watershed Management: Experiences from the PSNS ENVVEST Project.](#) (April 2001)

[Achieving Effective and Efficient Compliance through Watershed-Based Assessment and Partnering: Experiences from the PSNS ENVVEST Project](#) (Dec 2001)

TMDL Scope Report for Sinclair and Dyes Inlet (In Prep)

TMDL Study Plan for Fecal Coliform in Sinclair and Dyes Inlet (In Prep)

Regulatory Framework Report (In Prep)

9.2 Modeling Studies

Watershed Modeling

[MIKE-SHE and HSPF Intercomparison Report](#) (May 2001)

[Watershed Model Calibration and Verification Plan](#) (July 2001)

Modeling Report: Development and Calibration of HSPF Model for Chico Creek (In Prep, CTC has lead)

Modeling Report: Development and Calibration of HSPF Model for Gorst and Blackjack Creeks (In Prep, WES has lead)

Modeling Report: Development and Calibration of HSPF Model for Clear, Barker, and Strawberry Creeks (In Prep, SSC has lead)

Modeling Report: Intercalibration of HSPF Modes for Anderson Creek (In Prep, WES, SSC, and CTC)

[Watershed Water Quantity and Water Quality Modeling for Sinclair and Dyes Inlet](#) (In

Prep, WES et al.)

[GIS-Based Artificial Neural Network and Processed-Based HSPF Model for Watershed
Runoff in Sinclair and Dyes Inlet, WA](#) (In Press)

Receiving Water Modeling

Data review and data gap analysis for model parameters (Sep 2000)

[A Hydrodynamic Modeling Study Using CH3D for Sinclair Inlet, Draft Report](#). (Nov 99)

[Dispersion resulting from aggregating hydrodynamic properties in water quality
modeling](#). (Wang 2001)

[Lagrangian Drifts in the Tide and Wind-Driven Dyes Inlet](#) (Jun 2001)

[CH3D Users Manual](#) (July 2001)

[Fate and Transport Modeling for TMDL in Sinclair and Dyes Inlets](#) (In Prep SSC)

[CH3D-WASP-A Linked Hydrodynamic and Water Quality Model](#) (In Prep SSC)

Setup nutrient/eutrophication kinetics for WASP-EUTRO Completed Feb 2001

Setup contaminant kinetics WASP-TOXI Completed June 2001

9.3 Watershed Studies

GIS Layers (in prep)

[Benthic Macroinvertebrate Sampling Field Activity and Data Summary Report](#) (Draft
July 31, 2001)

[Watershed Assessment Plan](#) (Draft Aug 01)

[GIS-Based Approaches for Estimating Mean Annual Surface Runoff in Sinclair and Dyes
Inlet, WA](#) (WES et al.)

Watershed Monitoring Plan (in prep)

9.4 Ecological Studies

[Sinclair Inlet Water Quality Assessment](#) (Sept 99)

Sediment Flux Assessment in Sinclair and Dyes Inlets

[Workplan \(April 2000\)](#)

[Preliminary Report \(Feb 01\)](#)

[Direct, In-Situ Measurement of Diffusive Metal Fluxes from the Sediments of Sinclair and Dyes Inlet, Washington](#) (In Prep)

Final Report (In Prep)

Drogue and Current Meter Study for Dyes Inlet

[Workplan \(September 2000\)](#)

[Summary of Results \(March 2001\)](#) Dye Injection Study Plan; Dye Study Prelim. Results

Development of a Contaminant Mass Balance for Sediment in Sinclair and Dyes Inlets

[Quality Assurance Project Plan](#) (January 2002)

[Sampling Plan](#) (January 2002)

[Health and Safety Plan](#) (January 2002)

Ecorisk Problem Formulation Report (In Prep)

9.5 Core Capabilites

[Portal Specifications Report \(Jun 2001\)](#)

Data Inventory Annual Report (In Prep)

Glossary of Terms

Unless otherwise noted, definitions of these terms were obtained from U.S. EPA, PSWQAT 1997a, the Final Project Agreement (FPA - [US Navy, US EPA, and Washington State Department of Ecology 2000](#). Project ENVVEST: [Phase I Final Project Agreement for the Puget Sound Naval Shipyard](#), September 25, 2000) and CALTRANS 2000.)

Accuracy — The agreement between an analytical result and the true value. The difference between a measured value and the true or expected value represents an estimate of systematic error or net bias.

Aliquot — Individual, discrete sample volumes taken at set intervals (flow, time, or precipitation) or otherwise composited together to form a representative sample of a monitoring period flow (CALTRANS 2000).

Analyte — That which is analyzed.

Antecedent Moisture Conditions — The soil moisture conditions of the catchment or watershed at the beginning of a storm. These conditions affect the volume of runoff generated by a particular storm event (CALTRANS 2000).

Area-Velocity Flow Meter A flow meter that combines the use of a velocity sensor with a depth-measurement device. The velocity sensor uses Doppler technology to measure average velocity throughout the flow stream. The depth measurement is converted to cross-sectional area of flow, using user-input channel or pipe geometry. The flow is then calculated automatically from the cross-sectional flow area and the velocity (CALTRANS 2000).

Assessment - The evaluation process used to measure the performance or compliance of sampling and analysis activities.

Assimilative Capacity: The amount of contaminant load that can be discharged into a specific stream, river or water body without exceeding water quality standards or criteria. This refers to the ability of the water body to naturally absorb and use waste material without impairing water quality or harming aquatic life.(FPA 2000)

Audit - A systematic and independent examination to determine whether sampling and analysis activities and related results comply with planned practices, whether these practices are implemented effectively, and whether the nature and extent of these practices are suitable for the sampling and analysis activities they support.

Base Flow That part of the stream or surface water discharge that is not attributable to direct runoff from precipitation or snowmelt; it is usually sustained by water draining from natural storage in groundwater aquifers, lakes or wetlands (CALTRANS 2000).

Basin Plan A water quality control plan developed by a Regional Water Quality Control Board (RWQCB) for a specific geographic area. It identifies beneficial uses of waters and the water quality objectives needed to maintain these beneficial uses (CALTRANS 2000).

Batch - The number of samples that are prepared or analyzed with associated laboratory QC samples at one time. A typical batch size is 20 samples and may be dependent on the method.

Beneficial Uses Uses of water that must be protected against water quality degradation. These uses,

according to the California Porter-Cologne Water Quality Control Act, include domestic, municipal, agricultural and industrial supply; power generation; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves (CALTRANS 2000).

Benthic Community: The organisms that live at the bottom of aquatic ecosystem.(FPA 2000)

Best Available Technology Economically Achievable (BAT) The minimum technology-based treatment applicable to toxic chemicals and other non-conventional pollutants (e.g., trash, temperature, color). For storm water from construction activities, Caltrans defines BAT as available and effective pollution control techniques that are generally applicable to construction sites. Deployment of a BAT on a given site is subject to a site-specific determination of feasibility (CALTRANS 2000).

Best Conventional Pollutant Control Technology (BCT) The minimum technology-based treatment applicable to conventional constituents (total suspended solids, biochemical oxygen demand, etc.). For storm water from construction activities, Caltrans defines BCT as available and effective pollution control techniques that are generally applicable to construction sites. Deployment of a BCT on a given site is subject to a site-specific determination of feasibility (CALTRANS 2000).

Best Management Practice (BMP) As used in this document, the term BMP refers to operational activities or physical controls to minimize or eliminate pollutants in storm water and non-storm water discharges from the storm drain system. Accordingly, the term BMP refers to both structural and nonstructural controls that have direct effects on the release, transport, or discharge of pollutants (CALTRANS 2000).

Bias - The systematic or persistent distortion of a measurement process that causes errors in one direction.

Bioaccumulation: The net accumulation of a substance by an organism as a result of intake from all environmental sources.(FPA 2000)

Biodiversity: The state of having a large number of different species in an ecological system, indicative of a healthy, balanced environment.(FPA 2000)

Biota: The animal and plant life of a particular region.(FPA 2000)

Blank Samples Samples of contaminant-free blank water (see below) used to identify sample contamination during collection, handling, shipping, storage, laboratory handling and analysis. Blank samples can be collected at different points in the sampling/analysis process to identify sources of contamination (CALTRANS 2000).

Blank Water Water provided by a manufacturer or laboratory that is free of detectable concentrations of the constituent of interest. This water is used for blank samples to identify potential sources of environmental sample contamination during the sampling/analytical process (CALTRANS 2000).

Blank-corrected Result - Refers to an analytical result that has been corrected (mathematically or through analytical procedures) for the contribution of the method blank. The method blank should be processed concurrently. Any correction should account mathematically for all relevant weights, volumes, dilutions and other similar sample processing elements.

Bubbler (for water depth measuring) A device in which depth of water flow is determined by measuring the pressure needed to force bubbles out of a line submerged in the flow stream (CALTRANS 2000).

Calibration - The determination of the relationship between analytical response and concentration (or mass) of the analyte.

Catch Basin A storm drain inlet having a sump below the outlet to capture settled solids (CALTRANS 2000).

Catchment A drainage basin from which surface runoff is channeled into a single outflow (CALTRANS

2000).

Certified Reference Material - A reference material accompanied by, or traceable to, a certificate stating the concentration of chemicals contained in the material. The certificate is issued by an organization, public or private, that routinely certifies such material (e.g., National Institute of Standards and Technology, American Society for Testing and Materials).

CH3D: An acronym for “Curvilinear Hydrodynamics in Three-Dimensions”, which is a computer application for modeling the hydrodynamic processes large receiving waterbodies (including estuaries). Best know for its use in the modeling of Chesapeake Bay.(FPA 2000)

Chain of Custody - An unbroken trail of accountability that ensures the physical security of samples, data and records.

Check Standard - A QC sample prepared independently of calibration standards, analyzed exactly like the samples, and used to estimate analytical precision and indicate bias due to calibration.

Clean Water Act (CWA) The federal law that regulates the discharge of pollutants to waters of the U.S (most surface waters). The NPDES permit program implements the CWA. The CWA is also known as the Water Pollution Control Act Amendments. The California Water Code regulates discharges to groundwater (including discharges to the ground) and thus has wider jurisdiction (CALTRANS 2000).

Code of Federal Regulations (CFR) Document that codifies all rules of the executive departments and agencies of the federal government. It is divided into fifty volumes, known as titles. Title 40 of the CFR (referenced as 40 CFR) lists all federal environmental regulations (CALTRANS 2000).

Coefficient of Variation - The standard deviation expressed as a percentage of the mean. Also termed relative standard deviation or RSD.

Combined Sewer Overflow (CSO): A combined sewer carries both wastewater and stormwater runoff. CSO's typically discharge into receiving waters when storm water runoff exceeds the capacity of the combined sewer. This can result in the release of raw sewage to the environment.(FPA 2000)

Comparability - An indication of the confidence with which one data set can be compared to another.

Completeness - A measure of the amount of valid data obtained from sampling and analysis activities compared to the amount that was expected to be obtained.

Composite Sample A mixture of sample aliquots that forms one larger sample volume representative of a monitored flow (CALTRANS 2000).

Confidence Interval The range of values that a statistical estimate is within for a specified probability

Confined Spaces Storm sewers are classified as “confined spaces” under OSHA regulations. Regulations for entry into confined spaces are contained in 29 CFR 1910.146 and California Code of Regulation (CCR)-Title 8,-Article 108, confined spaces. The regulations require that no person shall enter a confined space without proper training and equipment. The risks associated with confined spaces include dangerous atmospheres, engulfment, falls, falling objects, and bodily harm due to explosion (CALTRANS 2000).

Constituent A substance found in dissolved, colloidal, or particulate form in water that can be measured as a concentration (CALTRANS 2000).

Contaminant A term often used interchangeably with “pollutant.” A constituent that can cause harmful or objectionable conditions in water at certain concentrations (CALTRANS 2000).

Contamination (Sample) A category of Quality Assurance/Quality Control (QA/QC) that is assessed by performing analyses on blank samples to identify sources of contamination that can occur during

collection, handling, shipment, storage, laboratory handling and analysis (CALTRANS 2000).

Control Limit(s) - A value or range of values against which results of QC sample analyses are compared in order to determine whether the performance of a system or method is acceptable. Control limits are typically statistically derived. When QC results exceed established control limits, appropriate corrective action should be taken to adjust the performance of the system or method.

Co-permittee A permittee to a NPDES permit that is only responsible for permit conditions relating to the discharges from its area of jurisdiction (CALTRANS 2000).

Corrective Action - Measures taken to remove, adjust, remedy or counteract a malfunction or error so that a standard or required condition is subsequently met.

Data Model: The system used for storing, linking, and presenting data in a database.(FPA 2000)

Data Quality Objectives (DQOs) Specify the quality of data required to support the specified objectives of the monitoring program. DQOs generally are used to determine the level of error considered to be acceptable in the data produced by the monitoring program; in large measure they are used to specify acceptable ranges of laboratory performance (CALTRANS 2000).

Data Quality Objectives (DQOs): Qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify the tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions (US EPA 1994c).

Defensible - the ability to withstand any reasonable challenge related to the veracity, integrity, or quality of the logical, technical, or scientific approach taken in a decision making process (US EPA 1994c).

Deployed Bivalve: Species of bivalve shellfish which are introduced into an area to study the effects of the local environment.(FPA 2000)

Detection Levels

Level of Quantitation (LOQ) The constituent concentration that is sufficiently greater than a blank that it can be detected within specified levels by good laboratories during routine operating conditions.

Method Detection Limit (MDL) The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. Concentrations reported by a laboratory that are between the MDL and RL (see below) are usually flagged by the laboratory as estimated "J," indicating the constituent is present but its concentration cannot be accurately quantified.

Minimum Level (ML) The concentration of the lowest initial calibration standard that gives an acceptable calibration point.

Practical Quantitation Level (PQL) The constituent concentration that can be determined within + 20 percent of the true concentration by 75 percent of the analytical laboratories tested in a performance evaluation study. Alternatively, if performance data are not available, the PQL is 5 x MDL for carcinogens and 10 x MDL for non-carcinogens.

Reporting Limit (RL) The lowest concentration of a constituent that can be reliably quantified within specified limits of precision and accuracy during routine laboratory operating conditions (CALTRANS 2000).

Dissolved Oxygen (DO): The amount of oxygen dissolved in water. It is also a measure of the amount of oxygen available for biochemical activity in a water body.(FPA 2000)

Drainage Swale A storm drainage conveyance structure, usually grassed or paved, designed to intercept, divert, and convey surface runoff (CALTRANS 2000).

Duplicate Analysis - Analysis performed on a second subsample in the same manner as the initial analysis, used to provide an indication of measurement precision.

Duplicate Samples Two samples taken at the same time from one location in order to assess precision.

Ecological Risk Assessment (ERA): The process of evaluating the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors.(FPA 2000)

Ecosystem: An interactive system that includes the organisms of a natural community associated by their shared physical, chemical, and geochemical environment.(FPA 2000)

Elutriate - A standard test used to predict the release of contaminants in sediment to a water column resulting from open water disposal of the sediment.

Environmental Justice: The fair treatment for people of all races, cultures, and incomes, regarding the development of environmental laws, regulations, and policies.(FPA 2000)

ENVVEST: A contraction for “**Environmental Investment**”, which is a joint EPA – DoD program to investigate innovative approaches to solving DoD environmental responsibilities while improving the environment and reducing cost.(FPA 2000)

Equipment Blanks Blank samples that are collected by passing blank water (contaminant free) through clean equipment and analyzing for the desired constituents in order to assess source contamination from equipment (CALTRANS 2000).

Estuary: Brackish-water area influenced by the tides where the mouth of a river or stream meets seawater.(FPA 2000)

Event Mean Concentration (EMC) A parameter that describes the average concentration of a given constituent at a specific location during a storm event. The EMC should be representative of the complete runoff hydrograph, and is defined as the total constituent mass transported in the runoff, divided by the total runoff volume. The EMC is normally derived by analytical measurement of the constituent concentration in one or more representative composite samples (CALTRANS 2000).

Facility Pollution Prevention Plan (FPPP) A plan which identifies the functional activities specific to the maintenance facility and the applicable BMPs and other procedures utilized by maintenance personnel to reduce the discharge of pollutants in storm water (CALTRANS 2000).

False Negative Decision Error - a false negative decision error occurs when the decision-maker does not reject the null hypothesis when the null hypothesis is actually false. In statistical terminology, a false negative decision error is also called a Type II error. The measure of the size of the error is expressed as a probability, usually referred to as "beta (β)"; this probability is also called the complement of power (US EPA 1994c).

False Positive Decision Error - a false positive decision error occurs when a decision-maker rejects the null hypothesis when the null hypothesis is actually true. In statistical terminology, a false positive decision error is also called a Type I error. The measure of the size of the error is expressed as a probability, usually referred to as "alpha (α)," the "level of significance," or "size of the critical region" (US EPA 1994c)

Field (matrix) spike — A sample prepared at the sampling point (i.e., in the field) by adding a known mass of the target analyte to a specified amount of the sample. Field matrix spikes are used, for example, to determine the effect of the sample preservation, shipment, storage, and preparation on analyte recovery efficiency (the analytical bias) (US EPA 1998b).

Field Blank - A simulated sample (usually consisting of laboratory pure water) that is taken through all phases of sample collection and analysis. Results of field blank analyses are used to assess the positive contribution from sample collection and analysis procedures to the final result.

Field Blanks Blank samples that are collected in the field using blank water (contaminant free) and the same methodologies used for sample collection. Field blanks are used to assess sample contamination due to

sampling and sample processing activities (CALTRANS 2000).

Field split samples — Two or more representative portions taken from the same sample and submitted for analysis to different laboratories to estimate interlaboratory precision (US EPA 1998b).

First Flush Typically referred to as the first 30 to 60 minutes or runoff from a rainfall event (CALTRANS 2000).

Flow-Proportional Composite Sample A composite of multiple sample aliquots, each of which represents a predetermined flow volume. The sample aliquots is collected at flow volume intervals and combined in a manner that creates a larger volume sample representative of the entire monitored flow period. The principal advantages of flow-proportional composites (over time-proportional composites or grab samples) are that flow-proportional composites are not biased by over- or under-sampling any part of the hydrograph, and they allow direct estimation of Event Mean Concentration (EMC) and Event Mass Load (EML), without making assumptions about the shape of the hydrograph or the relationship between pollutant concentrations and flow rates (CALTRANS 2000).

Flume A specially built reach of a channel (sometimes a prefabricated insert) that has a converging entrance, a throat section, and a diverging exit section. The throat area or slope (or both) of the flume is designed to differ from that of the channel, inducing a depth of flow which is proportional to flow rate. For each type of flume there is a functional relationship (mathematical equation) between depth and flow rate (CALTRANS 2000).

Gap Analysis: The process of comparing what data is available and what data is needed for a specific project. Then determining the best method to fill in the gaps in the data.(FPA 2000)

Grab Sample An individual sample collected at one specific site at one point in time. Analysis of a grab sample provides a snapshot of stormwater quality at a point in time (CALTRANS 2000).

Guideline - A suggested practice that is non-mandatory.

Holding time - The period of time a sample may be stored prior to its required analysis. While exceeding the holding time does not necessarily negate the veracity of analytical results, it causes the qualifying or “flagging” of any data not meeting all of the specified acceptance criteria (US EPA 1998b).

HSPF: An acronym for the “Hydrologic Simulation Program – FORTRAN”, a computer application for modeling pollutant loads and water quality in complex watersheds.(FPA 2000)

Hydrodynamic Model: A computer simulation of the movement and properties of a surface water system.(FPA 2000)

Hydrograph A graph of flow versus time for a given point (CALTRANS 2000).

Hydrologic Unit A subunit of a basin as defined by a Regional Water Quality Control Board (RWQCB) (CALTRANS 2000).

Hydrology: The science dealing with the properties, distribution, and circulation of water.(FPA 2000)

Hyetograph A graph of rainfall to a catchment versus time (CALTRANS 2000).

Hypothesis - A tentative assumption made to draw out and test its logical or empirical consequences. In hypothesis testing, the hypothesis is labeled "null" or "alternative", depending on the decision-maker's concerns for making a decision error.

Illicit Discharge Any discharge to a municipal storm sewer that is not composed entirely of stormwater. Discharges pursuant to a NPDES permit and those resulting from firefighting activities are exempted (CALTRANS 2000).

Indigenous Bivalve: Species of bivalve shellfish which occur naturally in an area.(FPA 2000)

Infiltration A complex process that allows runoff to penetrate the ground surface and flow through the upper soil surface (CALTRANS 2000).

Isotope Dilution Technique - An internal standard technique for quantification of organic compounds that uses a large number of stable isotopically labeled compounds spiked into the sample before extraction to provide recovery correction (i.e., to correct for compound loss during sample workup on a sample-specific basis). The labeled compounds are analogs of the target compounds and are assumed to behave similarly. The isotopic labels typically involve replacement of hydrogen atoms with deuterium or replacement of carbon-12 atoms with carbon-13 atoms.

Laboratory Control Sample A clean matrix spiked with known concentrations of target analytes that is used to evaluate laboratory accuracy, independent of matrix effects (CALTRANS 2000).

Laboratory split samples - Two or more representative portions taken from the same sample and analyzed by different laboratories to estimate the interlaboratory precision or variability and the data comparability (US EPA 1998b).

Limit of Quantitation (LOQ) - The minimum concentration of an analyte or category of analytes in a specific matrix that can be identified and quantified above the method detection limit and within specified limits of precision and bias during routine analytical operating conditions (US EPA 1998b).

Litter Any man-made object that can be captured in a ¼-inch mesh. The definition does not include materials of natural origin such as soils, gravel and vegetative debris. Examples of litter items include cartons, wrappers, paper or plastic cups, cans napkins and cigarette butts (CALTRANS 2000).

Matrix - The sample material in which the analytes of interest are found (e.g., water, sediment, tissue).

Matrix Spike - A QC sample created by adding known amounts of analytes of interest to an actual sample, usually prior to extraction or digestion. The matrix spike is analyzed using the normal analytical procedures. The result is then corrected for the analyte concentration determined in the unspiked sample and expressed as a percent recovery. This provides an indication of the sample matrix effect on the recovery of target analytes.

Matrix Spike/Matrix Spike Duplicate The laboratory process of splitting a stormwater sample into three aliquots, two of which are then “spiked” by adding known amounts of target constituents. The results of the analysis of the unspiked aliquot are compared to the spiked aliquots, and percent recovery of each spike is calculated in order to determine the accuracy of the analysis. The results of the two spiked aliquots are also compared to determine the precision of the analysis; this is accomplished by calculating the relative percent difference (RPD) between the spikes (CALTRANS 2000).

Media: The phases of the environment such as air, water, soil, sediments, and biota. (FPA 2000)

MESC: Acronym for “Marine Environmental Survey Capability”, a specially outfitted research vessel developed by the Navy’s SPAWAR System Center in San Diego. Used for taking state of the art measurements of a water body.(FPA 2000)

Method - A body of procedures and techniques for performing an activity that is systematically presented in the order in which they are to be executed.

Method Blank - A QC sample intended to determine the response at zero concentration of analyte. A clean matrix (generally water) known to be free of target analytes that is processed through the analytical procedure in the same manner as associated samples.

Method Blank Contaminant free water that is taken through the entire analytical procedure and used to evaluate contamination from laboratory procedures or conditions (CALTRANS 2000).

Method Detection Limit - The minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero; determined from analysis of a sample in a given matrix containing the analyte Code of Federal Regulations (40 CFR Part 136).

Monitoring Refers to a variety of activities and processes through which Caltrans will obtain information relevant to its implementation of the stormwater quality management program and to identify the need for and/or opportunities for revising or refining its program (CALTRANS 2000).

Must - A requirement that has to be met.

National Pollutant Discharge Elimination System (NPDES) The national program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits under the Clean Water Act (CALTRANS 2000).

Nonpoint Source Discharge A discharge from a diffuse source that cannot be attributed to any particular discharge point (i.e., without a single point of origin or not introduced into a receiving stream from a specific outlet) (CALTRANS 2000).

Non-Point Source Pollution: Pollution that is not released through pipes but rather originates from multiple sources over a relatively large area. Nonpoint sources can be divided into source activities related to either land or water use including failing septic systems, animal-keeping practices, agriculture, forestry, and urban and rural runoff. (FPA 2000)

Non-Storm Water Discharge Any discharge to a storm drain system or receiving water that is not comprised entirely of stormwater. Examples include process wastewaters, cooling water, and domestic wastewater discharges (CALTRANS 2000).

Normalize - Perform a data calculation in order to express results in terms of a reference parameter or characteristic.

NPDES: An acronym for the “National Pollutant Discharge Elimination System”. Established by the Clean Water Act, this federally mandated system is used to regulate point source and stormwater discharge.(FPA 2000)

Oil and Grease An analytical methodology that determines the concentration of groups of organic substances, primarily biological lipids and petroleum products, on the basis of their common solubility in an organic extracting solvent (CALTRANS 2000).

Oil Waste Oil of any kind or in any form, including but not limited to, petroleum, fuel oil, sludge, oil refuse, and oil mixed with wastes other than dredged soil (CALTRANS 2000).

Outfall The point source where a municipal storm sewer discharges to receiving waters (CALTRANS 2000).

Overland Flow The flow of water over the ground before it enters a defined channel (CALTRANS 2000).

PAH: An acronym for “Polyaromatic Hydrocarbons”, a type of persistent contaminants .(FPA 2000)

Pathogen A specific species of microorganism (a virus, bacteria, or protozoa) that can cause a communicable disease in the host organism (CALTRANS 2000).

Peak Flow The maximum rate of flow passing a given point during or after a rainfall event or snowmelt (CALTRANS 2000).

Percent RSD - Calculated by dividing the standard deviation by the mean and multiplying by 100.

Perennial Stream or Spring A stream that flows continuously throughout the year in dry as well as wet years

(CALTRANS 2000).

Permit Refers to the National Pollutant Discharge Elimination System (NPDES) General Permit and is an authorization, license, or equivalent control document, issued by the U.S. Environmental Protection Agency (EPA) or an approved state agency, to implement the requirements of the NPDES (CALTRANS 2000).

Point Source Any discernible, confined, and discrete conveyance or collection system, by which pollutants are or may be discharged. The term does not include return flows from irrigated agriculture or agricultural stormwater runoff (CALTRANS 2000).

Point Source Discharge: Pollutant discharges at a specific location from pipes, outfalls, and conveyance channels from either municipal or industrial wastewater treatment plants. Point sources can also include discharges of pollutants from streams and rivers into a receiving water body. Point source discharges are normally regulated under an NPDES permit. (FPA 2000)

Pollutant Any substance introduced into the environment that adversely affects the usefulness of a resource (CALTRANS 2000).

Pollutant Loading The quantity of a pollutant found in runoff expressed in mass per unit of time. Pollutant loadings are commonly expressed in units of tons/year or pounds/year (CALTRANS 2000).

Pollutant Trading: The concept of selling or trading load allocations between pollutant dischargers in order to promote overall pollutant load reduction.

Precision - The statistical agreement among independent measurements determined from repeated applications of a method under specified conditions. Usually expressed as relative percent difference (RPD) or coefficient of variation.

Pressure Transducer (for water depth measuring) A device that measures the pressure of the liquid above a pressure sensor to determine the depth of the steam flow (CALTRANS 2000).

Project - An organized set of activities within a program.

Project XL: An acronym for “Project Excellence and Leadership” created by the EPA to promote the creation of innovative solutions to environmental problems. The focus being better environmental performance at a reduced cost. (FPA 2000)

Qualified Data - Data to which data qualifiers have been assigned. Data qualifiers provide an indication that a performance specification in the qualified sample or an associated QC sample was not met.

Quality Assurance - An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item or service is of the type and quality needed and expected by the customer.

Quality Assurance Project Plan - A formal planning document describing in comprehensive detail the necessary QA, QC and other technical activities that must be implemented to ensure that the results of the work performed will satisfy the stated performance criteria.

Quality Control - The routine application of procedures for obtaining prescribed standards of performance in the monitoring and measurement process. Quality Control is an element of quality assurance. Analyses of QC samples and auditing/assessment are common quality control activities.

Quantification - The process of calculating the value of an analyte in a particular sample.

Receiving Water Limitations Permit limitations applied to dischargers to prevent violations of water quality standards (CALTRANS 2000).

Receiving Waters All surface waters (natural watercourse, lake, estuary or ocean) into which stormwater runoff is discharged (CALTRANS 2000).

Receiving Waters: Creeks, streams, rivers, lakes, estuaries, groundwater formations, or other bodies of water into which surface water and/or treated or untreated waste is discharged.(FPA 2000)

Recovery - The percentage difference between two measurements, before and after spiking, relative to the concentration spiked.

Reference Material - A material of known analyte composition which can be used for comparison of analytical results. The reported analyte concentrations have not been certified (see Certified Reference Material).

Reference Water Body: In a scientific study, this is a water body with similar physical characteristics to the studied water body, but with minimal human impact, used for comparison.(FPA 2000)

Regional Water Quality Control Board (RWQCB) The local agency responsible for the regulation of surface and ground water in California. The State Water Resources Control Board (SWRCB) sets overall policy that is implemented by the nine Regional Boards (CALTRANS 2000).

Relational Database: A collection of data where the different types of data are linked, or related, to each other in the database.(FPA 2000)

Relative Percent Difference (RPD)- Difference of two measurements x_1 and x_2 , divided by the mean of the measurements, multiplied by 100.

Relative Standard Deviation - see coefficient of Variation.

Replicate - One of several identical experiments, procedures or samples.

Representativeness - A measure of the degree to which data accurately and precisely represent an environmental characteristic or condition.

Reproducibility - The ability to produce the same results for a measurement. Often measured by determining the RPD, RSD or coefficient of variation for an analysis.

Reproducibility -The precision, usually expressed as variance, that measures the variability among the results of measurements of the same sample at different laboratories (US EPA 1998b).

Requirement - A formal statement of a need and the expected manner in which it is to be met (US EPA 1998b).

Runoff Volume The volume of storm water that runs over the surface of the ground and into a storm drainage system and receiving water (CALTRANS 2000).

Semivolatile Organic Compounds - Gas chromatographable organic compounds with moderate or low vapor pressures that can be extracted from samples using organic solvents.

Should - Refers to a highly recommended practice. The practice may be mandatory, depending on the exact conditions of data generation.

Site Imperviousness The fraction of land surface that does not allow infiltration of rainfall at the start of a rainfall event (CALTRANS 2000).

Site Runoff Coefficient (C) A unitless coefficient used in the rational method that is ratio of the maximum rate of runoff to the uniform rate of rainfall times the watershed area (CALTRANS 2000).

Spike - A substance that is added to an environmental sample to increase the concentration of target analytes

by known amounts; used to assess measurement accuracy (spike recovery). Spike duplicates are used to assess measurement precision (US EPA 1998b).

Split samples - Two or more representative portions taken from one sample in the field or in the laboratory and analyzed by different analysts or laboratories. Split samples are quality control (QC) samples that are used to assess analytical variability and comparability (US EPA 1998b).

Split Samples Samples that are split into two samples by the laboratory and each analyzed in order to assess laboratory precision. Also called laboratory duplicates, which is a misnomer (CALTRANS 2000).

Stakeholders: Any agency, organization, or individual that is involved in or is affected by the decisions made in the management of the watershed.(FPA 2000)

Standard - A substance or material, the properties of which are believed to be known with sufficient accuracy to permit its use to evaluate the same property of a sample. In chemical measurements, standard often describes a solution of analytes used to calibrate an instrument.

Standard Operating Procedure (SOP) - A written document that details the method for an operation, analysis, or action with thoroughly prescribed techniques and steps and that is officially approved as the method for performing certain routine or repetitive tasks (US EPA 1998b).

Standard Reference Material - A material with known properties produced and distributed by the U. S. National Institute of Standards and Technology (NIST).

Storm Drain Inlet A drainage structure that collects surface runoff and conveys it to an underground storm drain system (CALTRANS 2000).

Storm Water Drainage System Streets, gutters, inlets, conduits, natural or artificial drains, channels and watercourses, or other facilities that are used for the purpose of collecting, storing, transporting, or disposing of storm water (CALTRANS 2000).

Storm Water Management Practice Any activities, prohibitions or modifications of practices, maintenance procedures, and other physical, structural and/or managerial practices to prevent or reduce stormwater pollution of receiving waters (CALTRANS 2000).

Stormwater Runoff: Rainfall that does not evaporate or infiltrate the ground but instead flows onto adjacent land or waterbodies or is routed into a drain or sewer system.(FPA 2000)

Stressor: Any physical, chemical, or biological entity which can induce an adverse response.(FPA 2000)

Subsamples Volumes poured from a larger volume composite sample into individual constituent bottles (CALTRANS 2000).

Sump In drainage, any low area that does not permit the escape of water by gravity flow (CALTRANS 2000).

Surface Waters: Water that is present above the substrate or soil surface. Usually refers to natural waterbodies such as rivers, streams, lakes, and estuaries.(FPA 2000)

Surrogate Spike Compound - A compound that has characteristics similar to that of a compound of interest, is not expected to be found in environmental samples, and is added to a sample prior to extraction. The surrogate compound can be used to estimate the recovery of chemicals in the sample.

Target Analytes (or Target Compounds) - One or more elements or compounds which are intended to be determined by an analytical procedure (in contrast to tentatively identified compounds).

Temporary Construction Site BMPs BMPs temporarily used to address a short-term stormwater contamination threat (CALTRANS 2000).

Tentatively Identified Compounds - Chemicals identified in a sample on the basis of mass spectral characteristics held in common with a reference mass spectra of a known chemical. These compounds cannot be more confidently identified unless a reliable standard of the compound is obtained and is confirmed to co-elute with the tentatively identified compound and generate similar mass spectra using the same GC/MS.

Time of Concentration The time required for water to flow from the most hydraulically remote point of the drainage area to the location being sampled, assuming uniform distribution of rainfall intensity throughout the area (CALTRANS 2000).

Topography: The physical features and shape of the earth's surface.(FPA 2000)

Total Maximum Daily Load (TMDL): A tool for establishing the maximum allowable loadings of a particular pollutant into a surface water body to meet predetermined water quality criteria. It is based on the sum of the individual point and non-point pollutant allocations into a specific water body, along with a margin of safety, that is required to attain water quality goals. The margin of safety reflects the scientific uncertainty in the actual measurement of the point and non-point loadings and assimilative capacity of the water body.(FPA 2000)

Total Petroleum Hydrocarbons (TPH) Petroleum products of varying chain lengths of hydrocarbons that are classified in the following fractions (in increasing order of hydrocarbon chain length): BTEX (benzene, ethylbenzene, toluene, and xylene); kerosene; diesel; jet fuel; fuel oil; and lubricating oil. In order to quantify TPH concentrations in water samples, the different fractions must be analyzed for separately (eg., TPH-BTEX; TPH-Diesel; etc.) (CALTRANS 2000).

Toxic Pollutants Those pollutants defined in the federal regulations at 40 CFR 401.15 (pursuant to Section 307(a)(1) of the Clean Water Act). These pollutants include copper, lead, zinc, many chlorinated organic compounds including pesticides, and other constituents sometimes found in wastewater (CALTRANS 2000).

Toxic Thresholds: The amount of a pollutant in an ecological unit where toxic effects begin to appear.(FPA 2000)

Translators: Factors or numbers used to loading of one form of a pollutant based on measurements of a different form of the pollutant.(FPA 2000)

Transported Solids Any object that can pass through a ¼-inch mesh and can fit into the sampler intake strainer at the end of the Teflon tubing (CALTRANS 2000).

Type I error - A Type I error occurs when a decision-maker rejects the null hypothesis when it is actually true. See false positive decision error (US EPA 1994c).

Type II error - A Type II error occurs when the decision-maker fails to reject the null hypothesis when it is actually false. See false negative decision error (US EPA 1994c).

Ultrasonic (for water depth measuring) A device that measures depth by transmitting an ultra sound pulse from a sensor mounted above the stream and measuring the time for the echo to return from the flow stream surface. This measuring device must be placed in a secure location, where it will not be affected by wind, temperature flux, etc (CALTRANS 2000).

Uniform Flow Flow in which the velocities are the same in both magnitude and direction from point to point along a conveyance; this can only occur in a channel of constant cross section, roughness, and slope in the direction of flow. The conditions for uniform flow must prevail in order to use Manning's equation for flow measurement.

Validation - Confirmation by examination and provision of objective evidence that the particular

requirements for a specific intended use are fulfilled. Can refer to a process whereby environmental data are determined by an independent entity to be complete and final (i.e., subject to no further change), and to have their value for the intended use described by both qualitative and quantitative statements.

Volatile Organic Compounds - Organic compounds with high vapor pressures that tend to evaporate readily from a sample.

Waste Load Allocation (WLA) The maximum load of a given constituent each discharger is allowed to release into a particular waterway. A WLA is required for each specific constituent being regulated; the portion of a stream's total assimilation capacity assigned to an individual discharge (CALTRANS 2000).

Water Quality Objectives (WQO) Numerical or narrative limits on constituents or characteristics of water designed to protect designated beneficial uses of the water. California's WQOs are established by the State and Regional Boards in the Water Quality Control Plans or Basin Plans (CALTRANS 2000).

Water Quality Parameter A physical, chemical, or biological characteristic, property, or representation of the quality of water. The parameter may be stated in qualitative terms (for example, an aesthetic property such as the presence or absence of trash) or in quantitative terms (for example, the concentration of a constituent in water in mass per unit volume) (CALTRANS 2000) (CALTRANS 2000).

Water Quality Standards A combination of the designated beneficial uses of water and water quality objectives (criteria) to protect those uses. Water quality standards are enforceable limits for the bodies of surface or ground waters for which they are established; they are promulgated by the State and Regional Boards in California (CALTRANS 2000).

Watershed Model: A computer simulation of how water and contaminants move over the land of a watershed and into the receiving waters. (FPA 2000)

Watershed: The area of land from which rainfall drains into a stream or other select water body. Ridges of higher ground generally form the boundaries between watersheds. (FPA 2000)

Weir A device that has a crest and some side containment of known geometric shape, such as a V, trapezoid, or rectangle, and is used to measure flow rate in an open channel (CALTRANS 2000).

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